MX-774
GROUND TO GROUND MISSILE

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NOVEMBER 1947

CVAC REPORT 1496-13

CONSOLIDATED VULTEE

SAN DIEGO DIVISION, SAN DIEGO, CALIFORNIA

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FOREWORD

PROJECT MX-774, ORIGINALLY A STUDY AND RESEARCH PROGRAM LEADING TO THE PRACTICAL DESIGN OF A SUPERSONIC-SPEED GUIDED MISSILE OF 1500 TO 5000 MILES RANGE, HAS NOW BEEN LIMITED TO THE DESIGN, FABRICATION AND FLIGHT TESTING OF SUPERSONIC TEST VEHICLES. A LIMITED AMOUNT OF WORK IS CONTINUING ON STUDY AND DEVELOPMENT OF LONG-RANGE GUIDANCE SYSTEMS AND STUDIES OF HIGH VELOCITY WARHEAD TEMPERATURES.

THIS REPORT, THE THIRTEENTH IN THE SERIES, SUMMARIZES PROGRESS MADE DURING JULY AND AUGUST 1947 IN MISSILE DESIGN, IN STABILIZATION AND GUIDANCE DEVELOPMENTS, AND IN PREPARATIONS FOR TESTING THE MX-774 VEHICLES BEING FABRICATED.

REPORT CONTENTS

ILLUSTRATIONS

SECTION I

SUMMARY

A. PROBLEMS INITIATED - WORK CONDUCTED

THE "TWO-STAGE" STUDIES WERE CONCLUDED EARLY IN JULY.

ANALYTICAL STUDIES

CONTINUING AERODYNAMIC INVESTIGATIONS ON THE SINGLE STAGE MX-774 TEST VEHICLE ARE PRESENTED IN SECTION IV (PAGE 13). A STATIC STABILITY MARGIN OF 8.2 PERCENT BODY LENGTH IS INDICATED AT THE CRITICAL CONDITION OF M = 4.0 DURING VERTICAL FLIGHT. PERFORMANCE CHARACTERISTICS SHOW A MAXIMUM ASCENDING VELOCITY OF 5050 FT/SEC (M = 4.41) WHILE MAXIMUM ALTITUDE ATTAINED WOULD BE 521,000 FEET. A POSSIBLE RANGE OF 174 STATUTE MILES WOULD BE OBTAINED WITH AN INITIAL FLIGHT PATH ANGLE OF 75 DEGREES. BEHAVIOR OF THE MISSILE ON APPLICATION OF FLIGHT PATH CONTROLS IS UNDER STUDY IN ORDER TO DETERMINE SUITABLE CONSTANTS OF PROPORTIONALITY BETWEEN GUIDANCE SIGNALS AND MISSILE RESPONSE.

ROLL STABILIZATION SYSTEM ANALYSIS WAS BEGUN BUT, WHILE ACCEPTABLE SERVO CONSTANTS WERE ARRIVED AT FOR POWERED FLIGHT CONDITIONS, A TENDENCY TOWARD INSTABILITY NEAR FUEL SHUTOFF NECESSITATES FURTHER WORK.

STABILIZATION AND CONTROLS

A SUCCESSFUL OPERATIONAL TEST RUN OF THE STABILIZATION SYSTEM AMPLIFIER AND GYRO PANEL ASSEMBLY WAS MADE ON THE FLIGHT SIMULATOR UNIT AND IN ASSOCIATION WITH THE REST OF THE STABILIZATION EQUIPMENT. OTHER STABILIZATION SYSTEM EQUIPMENT DEVELOPMENT AND TESTS ARE ALSO REPORTED IN SECTION VI (PAGE 33).

GUIDANCE AND TRACKING

SECTION VII (PAGE 41) DESCRIBES A HIGHLY SUCCESSFUL AUTOMATICALLY GUIDED FLIGHT, A SUBCLIMAX OF THE MAGNETIC NAVIGATION STUDIES. THE DISTANCE FLOWN WAS 160 MILES, AND THE COURSE WAS FOLLOWED TO THE VICINITY OF THE TARGET. A MAP OF THE FLIGHT IS SHOWN ON PAGE 40.

THE PRECISION MISSILE TRACKING SYSTEM DEVELOPMENT HAS PROGRESSED TO THE EXPERIMENTAL MOCKUP AND TESTING STAGE.

AZIMUTH TRACKER COMPONENTS HAVE BEEN ASSEMBLED, AND ELEVATION TRACKER COMPONENTS ARE NEARING COMPLETION. OPERATION OF POSITION TRACKING EQUIPMENT AND BLOCK DIAGRAMS OF THE SYSTEMS ARE DETAILED IN SECTION VII.

DOPPLER SPEEDOMETER FLIGHT TESTS WERE MADE AT AN ALTITUDE OF 7000 FEET AND A RANGE OF 100 MILES. OPERATION PROVED VERY SATISFACTORY. WORK ON A DOPPLER RANGE MEASUREMENT SYSTEM WAS INITIATED AS WAS DEVELOPMENT OF COMMAND CONTROL EQUIPMENT FOR GUIDANCE OF TEST MISSILES. A STUDY OF RANGE MEASUREMENT SYSTEMS WAS COMPLETED AND WILL BE RELEASED AS A SEPARATE REPORT.

TELEMETERING

A SATISFACTORY FLIGHT TEST OF THE AIRBORNE TELEMETERING FOR TEST MISSILE NO. 1 WAS MADE. EXCELLENT TELEMETERING SIGNALS WERE RECORDED BY THE GROUND STATION OVER DISTANCES UP TO 250 MILES. REARRANGEMENT OF TELEMETERING EQUIPMENT WITHIN THE MX-774 TEST MISSILE IS BEING WORKED OUT. DEVELOPMENT OF THE VACUUM TUBE GYRO WAS DEFERRED FOR MORE URGENT PROJECTS.

DESIGN OF ANTENNAS FOR HANDLING SIGNALS FOR THE DOPPLER SPEEDOMETER AND THE TELEMETERING HAS BEEN FINISHED. THESE FLUSH-STRIP ANTENNAS WILL BE MOUNTED IN THE TAIL FINS OF THE TEST VEHICLES.

CONSTRUCTION OF THE CAMERA LOCATOR BEACON TRANSMITTER IS NEARLY COMPLETE. THE BEACON WILL FACILITATE LOCATING THE TEST VEHICLE FLIGHT TEST RECORDS WHEN THE REMOVABLE NOSE OF THE VEHICLE HAS BEEN PARACHUTED TO EARTH. THE RADAR TRACKING-ASSIST BEACON RECEIVER AND TRANSMITTER HAVE BEEN CONSTRUCTED AND ARE DESCRIBED ON PAGE 58.

TEST OPERATIONS

THE STATIC FIRING TEST SITE AT POINT LOMA, SAN DIEGO, IS NEARLY FINISHED. INSTRUMENTATION OF CONTROL HOUSE AND TOWER HAS BEEN STARTED. PLANS ARE READY FOR COMPLETE PHOTOGRAPHIC CONVERAGE OF THE FIRING TEST.

PLANNING FOR THE MX-774 FLIGHT TESTS CONTINUES.

B. PROJECT CONTACTS

VISIT FROM SIGNAL CORPS PERSONNEL. SOUNDING ROCKETS WERE DISCUSSED AND CURVES OF ALTITUDE VS PAYLOAD FOR TEST VEHICLE FURNISHED. AS A RESULT A REPORT WAS PREPARED AND FORWARDED TO THE SIGNAL CORPS GIVING A DESCRIPTICN OF THE SINGLE STAGE TEST VEHICLE, MODEL 6002, ADAPTED TO USE AS A SOUNDING ROCKET.

VISIT FROM CHEMICAL CORPS PERSONNEL. CHEMICAL WARHEADS AND SPOTTING CHARGES FOR TEST VEHICLE WARHEAD WERE DISCUSSED. THE CHEMICAL CORPS IS INITIATING A TEST PROGRAM INTENDED TO DETERMINE THE MOST SUITABLE SPOTTING CHARGE FOR THE MX-774 TEST VEHICLE WARHEAD.

SECTION II

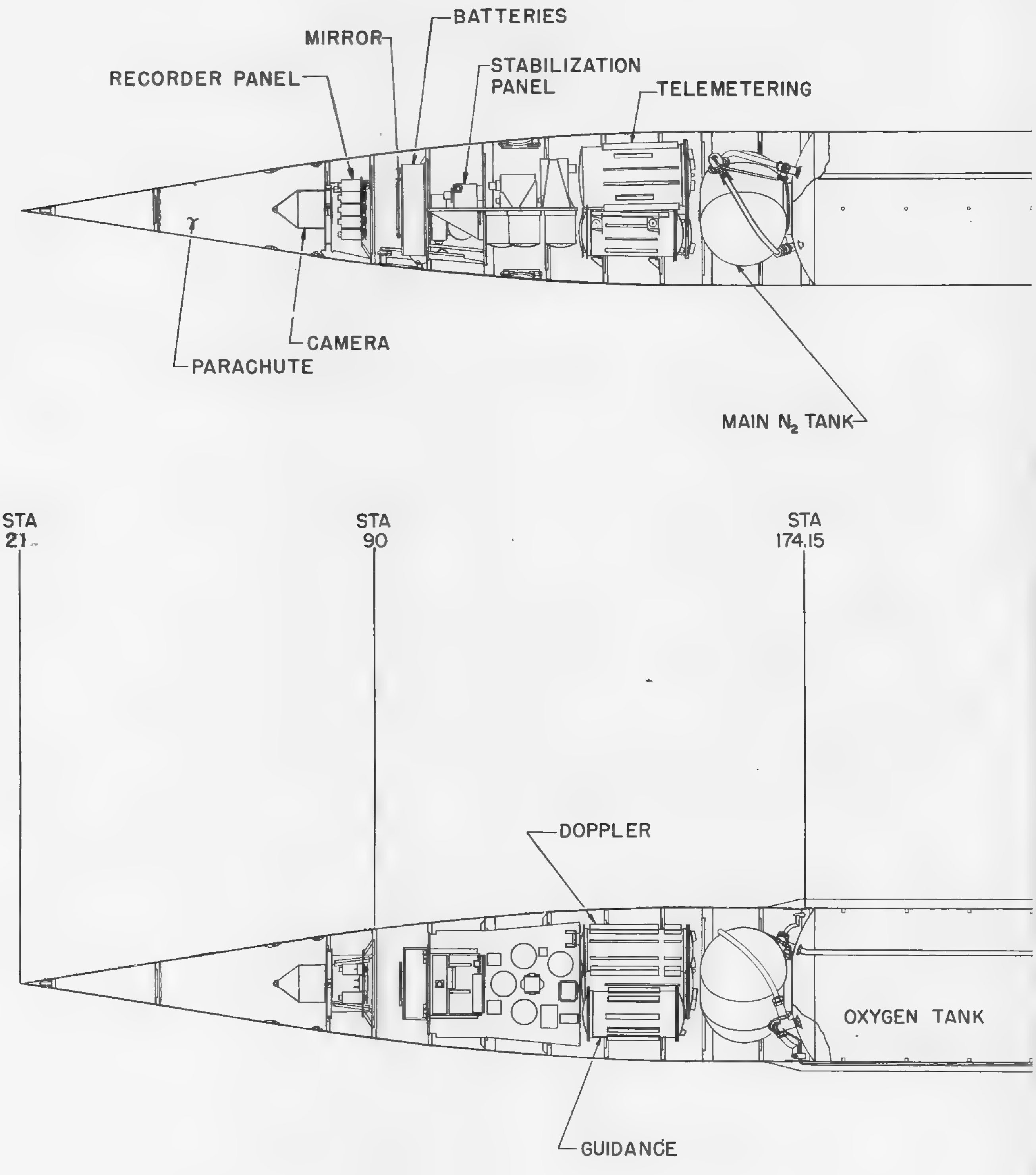
DESCRIPTION OF MISSILE

A. GENERAL DESCRIPTION

THE MX-774 TEST VEHICLE IS A SELF-LAUNCHED, HIGH-ALTITUDE SUPERSONIC ROCKET PROJECTILE PROPELLED BY AN ALCOHOL-OXYGEN MOTOR OF 8000-POUNDS THRUST. IT IS BEING DEVELOPED TO STUDY POWER PLANT, CONTROL, GUIDANCE, AERODYNAMIC, AND TRAJECTORY PROBLEMS. THE MX-774 INBOARD PROFILE IS SHOWN IN FIGURE I.

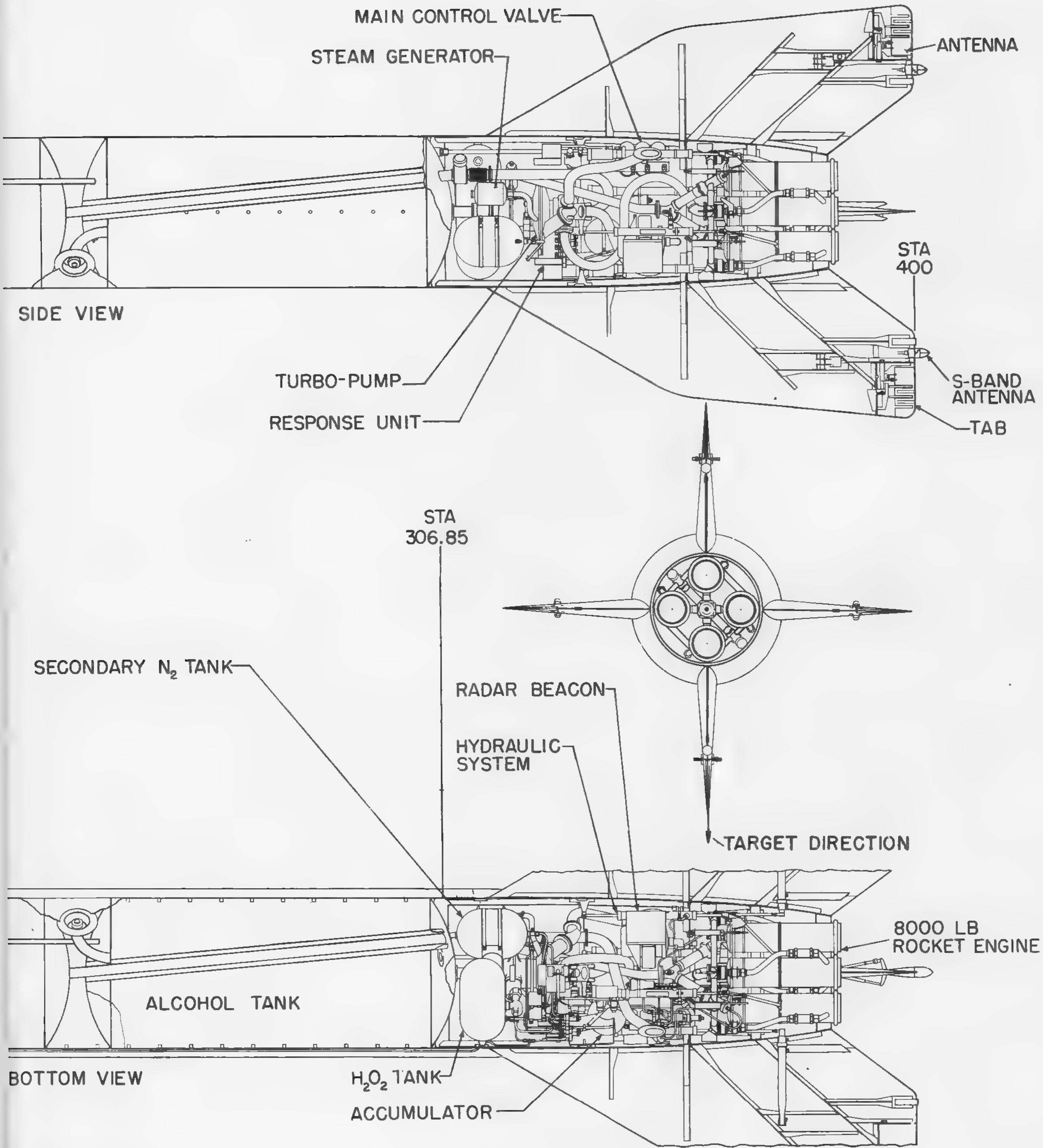
B. PRINCIPAL DIMENSIONS AND PARTICULARS

GENERAL		
SPAN	82.24	INCHES
LENGTH (OVERALL)	379	INCHES
HEIGHT AND WIDTH (MAXIMUM)	82.24	INCHES
GROSS WEIGHT	4203	POUNDS
FINS		
AIRFOIL SECTION	MODIFIED DOUBLE WEDGE	
ROOT CHORD	69	INCHES
OVERALL CHORD	85	INCHES
INCIDENCE	0	DEGREES
DIHEDRAL	0	DEGREES
SWEEPBACK	60	DEGREES
AREA (PER FIN)	10	SQ FT
TAB AREA (PER TAB)	0.48	SQ FT
FUSELAGE		
DIAMETER	30	INCHES
LENGTH	362	INCHES
ROCKET CYLINDER RANGE OF MOVEMENT		
PITCH AXIS (2 CYL) PITCH CONTROL	5	DEGREES
PITCH AXIS (2 CYL) ROLL CONTROL	5	DEGREES
YAW AXIS (2 CYL) YAW CONTROL	5	DEGREES
YAW AXIS (2 CYL) ROLL CONTROL	5	DEGREES
TANK CAPACITIES		
FUEL - ALCOHOL	196	GALLONS
OXIDIZER-LIQUID OXYGEN	167	GALLONS
NITROGEN-PROPELLANT TANK PRESSURIZING	4140 CU IN	1090 PSI
NITROGEN-H_2O_2 TANK PRESSURIZING	794 CU IN	2000 PSI
H_2O_2 TANK	5.3	GALLONS


BATTERIES
MIRROR
RECORDER PANEL
STABILIZATION PANEL
TELEMETERING
CAMERA
PARACHUTE
MAIN N_2 TANK
STA 21
STA 90
STA 174.15
DOPPLER
OXYGEN TANK
GUIDANCE

TE

(NO.



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C. FUSELAGE

THE FUSELAGE IS COMPOSED OF A REMOVABLE TAIL CONE, A TAIL ASSEMBLY INCLUDING THE FINS, A CENTER SECTION COMPRISED OF THE OXYGEN AND ALCOHOL TANKS, AND A FORWARD AND AFT NOSE ASSEMBLY.

THE ALCOHOL AND LIQUID OXYGEN TANKS IN THE CENTER SECTION ARE OF WELDED ALUMINUM ALLOY CONSTRUCTION. TWO FAIRINGS WHICH HOUSE WIRES AND PRESSURE LINES ARE ATTACHED TO THE TANKS AND MAY BE REMOVED. ACCESS TO THE COMPARTMENT BETWEEN THE TANKS IS BY MEANS OF A REMOVABLE PANEL. THE ALCOHOL TANK IS FILLED THROUGH A FILLER NECK LOCATED BETWEEN THE TWO TANKS. THE LIQUID-OXYGEN TANK IS FILLED THROUGH A FILLER VALVE LOCATED BETWEEN THE TANKS.

D. TAIL GROUP

THE TAIL GROUP CONSISTS OF FOUR FULL-CANTILEVER SURFACES, EACH CONTAINING A CONTROLLED TAB. BASIC STRUCTURE CONSISTS OF SPANWISE FABRICATED ALUMINUM ALLOY SHEET RIBS AND SPARS COVERED WITH ALUMINUM ALLOY SKIN.

ONE PAIR OF TABS PERFORMS A SLOW TRIM ROLL CORRECTION AND IS ACTUATED THROUGH FLEXIBLE SHAFTS BY A LEAR ACTUATOR TO ATTAIN FULL 20 DEGREE DEFLECTION IN EITHER DIRECTION IN 11 SECONDS. LIMIT SWITCHES ON THE ROLL MASTER HYDRAULIC CYLINDER ENERGIZE THE SLOW TRIM TAB ACTUATOR WHEN THE SWIVELING ROCKET MOTORS HAVE ATTAINED 1-DEGREE ROLL DEFLECTION.

THE SECOND PAIR OF TABS ARE CONNECTED THROUGH A TORQUE TUBE AND LINKAGE TO A CORRESPONDING PAIR OF ROCKET CYLINDERS AND ARE DEFLECTED THROUGH THEIR 20 DEGREE DEFLECTION IN EITHER DIRECTION BY 10 DEGREES DEFLECTION OF THE ROCKET CYLINDER.

THE TAIL CONE IS AN ALUMINUM ALLOY SEMI-MONOCOQUE STRUCTURE WHICH MAY BE REMOVED WITHOUT ANY DISTURBANCE OF MECHANICAL PARTS. THE PRINCIPAL FUNCTION OF THE TAIL CONE IS TO ACT AS A FAIRING AND IT IS REMOVABLE TO PROVIDE FOR ENGINE ACCESS AND REMOVAL.

THE EMPENNAGE ASSEMBLY INCLUDES THE TAIL ASSEMBLY WHICH IS AN ALUMINUM ALLOY SEMI-MONOCOQUE STRUCTURE ACTING AS THE HOUSING AND SUPPORT FOR THE POWER PLANT AND THE FINS WHICH ARE ATTACHED TO THE TAIL ASSEMBLY WITH SCREWS AND RIVETS. ACCESS DOORS, CONSTITUTING ONE QUARTER OF THE TAIL ASSEMBLY SKIN, ARE PROVIDED. THE EMPENNAGE ASSEMBLY, INCLUDING THE

POWER PLANT COMPONENTS, CAN BE REMOVED FROM THE MAIN FUSELAGE ASSEMBLY AFTER REMOVAL OF THE FAIRINGS AND DISCONNECTION AT THE ALCOHOL LINE FLANGE, THE OXYGEN LINE FLANGE, THE CONTROL CYLINDER ALCOHOL RETURN LINE FITTING, THE NITROGEN PRESSURE LINE FITTING, AND THE ELECTRICAL DISCONNECTS IN THE FAIRING TUNNELS.

E. NOSE ASSEMBLIES

THE FORWARD NOSE ASSEMBLY IS AN ALUMINUM ALLOY SEMI-MONOCOQUE STRUCTURE WHICH HOUSES THE PARACHUTE AND IS SEVERED FROM THE MISSILE DURING FLIGHT BY MEANS OF AN ELECTRICALLY DETONATED "PRIMA-CHORD". THE FORWARD NOSE MAY BE DISASSEMBLED FROM THE MISSILE LEAVING THE CHUTE ATTACHED TO THE AFT NOSE ASSEMBLY.

THE AFT NOSE ASSEMBLY IS OF ALUMINUM ALLOY SEMI-MONOCOQUE CONSTRUCTION AND HOUSES THE INTELLIGENCE AND GUIDANCE EQUIPMENT AND USEFUL LOAD OF THE MISSILE. IT MAY BE REMOVED FROM THE TANK SECTION AFTER REMOVAL OF THE FAIRING.

F. POWER PLANT

THE POWER PLANT COMPRISES A REACTION MOTORS INCORPORATED ALCOHOL-OXYGEN BURNING ROCKET ENGINE MOUNTED IN A TUBULAR STEEL MOUNT AND A FUEL AND OXIDIZER SYSTEM THROUGH WHICH ALCOHOL AND OXYGEN ARE SUPPLIED TO THE ROCKET CYLINDERS AT 450 PSI PRESSURE BY A TURBO-PUMP DRIVEN BY THE PRODUCTS OF DISSOCIATION OF H_2O_2 WHEN ACTED UPON BY A CATYLIST.

THE 8000-C4 ENGINE CONSISTS OF FOUR 2000-POUND THRUST ROCKET CYLINDERS SWIVEL MOUNTED TO A TUBULAR STEEL MOUNT WHICH ALSO SERVES AS THE ALCOHOL MANIFOLD. ALCOHOL IS FED FROM THE MANIFOLD TO THE CYLINDER THROUGH A SEALED BALL JOINT AND A CHECK VALVE. MOUNTED IN THE MANIFOLD ARE TWO RMI PROPELLANT VALVES WHICH REGULATE THE FLOW FROM THE ALCOHOL PUMP. OXYGEN IS FED DIRECTLY FROM THE OXYGEN PROPELLANT VALVE THROUGH A SWIVELING JOINT AND CHECK VALVE TO EACH CYLINDER. THE SWIVELING JOINT OXYGEN CONNECTION IS SEALED BY MEANS OF A PRESSURE DIAPHRAGM LOADED METAL SEAT. THE CYLINDERS ARE SWIVELED PLUS OR MINUS 10 DEGREES IN A TANGENTIAL DIRECTION ABOUT FOUR RADIAL AXIS OF 90 DEGREES TO EACH OTHER BY MEANS OF A HYDRAULIC ACTUATING CYLINDER OPERATING ON 11.5-INCH ARMS.

SECTION III
DESIGN AND FABRICATION

A. GENERAL

CURRENT WEIGHT STATUS OF THE SINGLE-STAGE TEST VEHICLE IS GIVEN BY TABLE I (FIG. 2). WHILE WEIGHT FABRICATED (613 POUNDS) IS REPORTED FOR THE FIRST FLIGHT TEST VEHICLE ONLY, SPARES PROVIDE A SIMILAR WEIGHT PROGRESS FOR THE OTHER FLIGHT TEST ARTICLES. PRODUCTION RELEASE HAS BEEN SET AT THREE MISSILES.

CG TRAVEL IN THE CURRENT DESIGN FOR THE FLIGHT TEST ARTICLES IS SHOWN IN FIGURE 3.

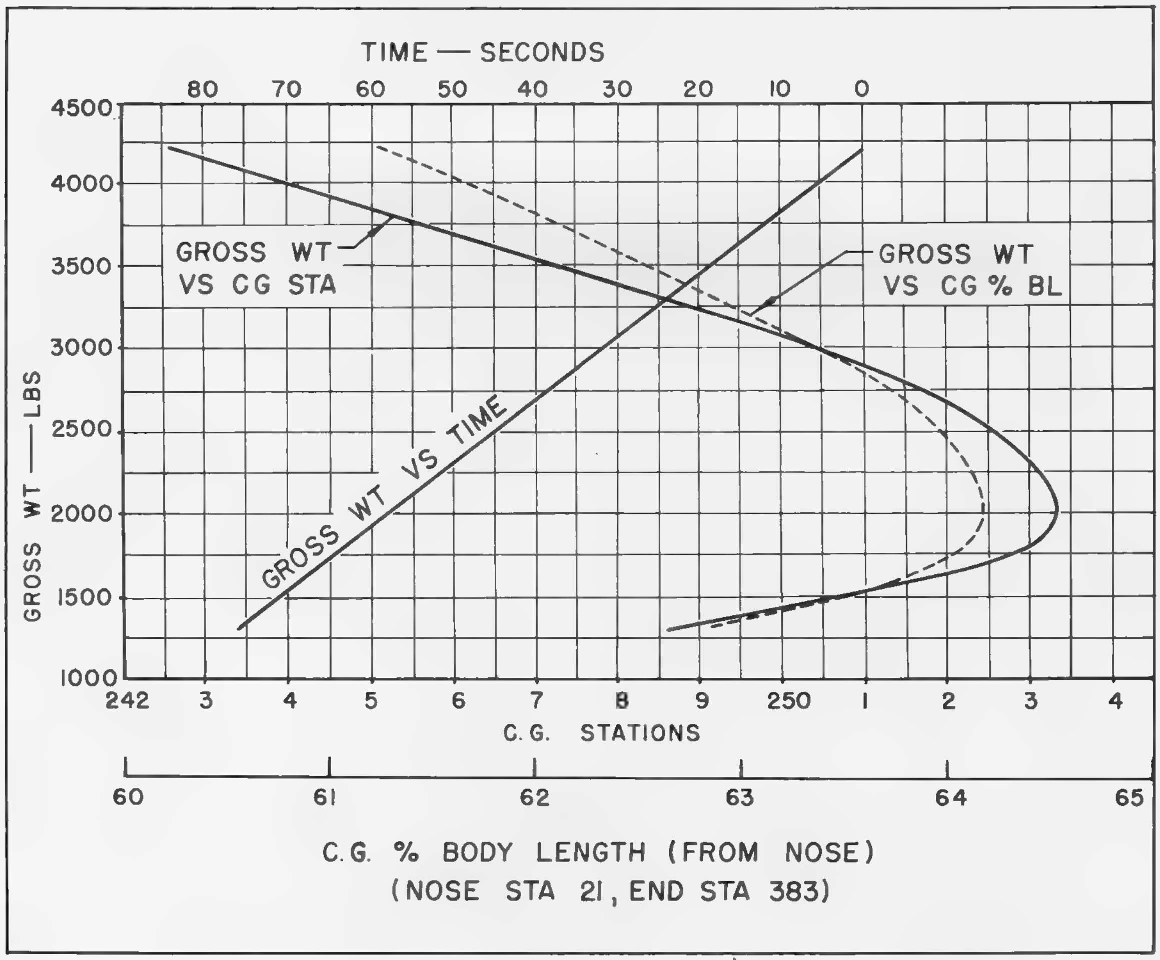

FIG. 3 -- GROSS WEIGHT VS CG AND TIME

ITEM	PREVIOUS REPORT		PRESENT REPORT		CHANGES
WEIGHT EMPTY	(1288.0)		(1296.0)		(+8.0)
BODY GROUP	234.0		238.0		+4.0
FIN GROUP	104.0		104.0		0
POWER PLANT GROUP	417.0		426.0		+9.0
FIXED EQUIPMENT GROUP	301.0		302.0		+1.0
FLIGHT TEST EQUIPMENT	232.0		226.0		-6.0
USEFUL LOAD	(2915.0)		(2915.0)		(0)
ETHANOL	1350.0		1350.0		0
LIQUID OXYGEN	1500.0		1500.0		0
HYDROGEN PEROXIDE	65.0		65.0		0
GROSS WEIGHT	4203.0		4211.0		+8.0
CG IN % B.L., FROM NOSE					
WEIGHT EMPTY	61.3		62.9		+1.6
GROSS WEIGHT	60.7		61.2		+0.5
STATUS OF WEIGHT DATA	LB	%	LB	%	
WEIGHT EMPTY	(1288)		(1296)		
ESTIMATED	305	24	204	16	
CALCULATED	326	25	326	25	
ACTUAL	657	51	766	59	
CONTRACTOR FABRIC. WGT.	(592)		(613)		
ESTIMATED	100	17	51	8	
CALCULATED	105	18	167	27	
ACTUAL	387	65	395	65	

EXPLANATION OF CHANGES	CHANGES POUNDS
WEIGHT EMPTY	
BODY GROUP - PARACHUTE STRUCTURE REVISED	+ 4.0
POWER PLANT GROUP	
MOTOR PROPELLANT SYSTEM ADD BASE FOR OXYGEN GAUGE	+ 1.0
PRESSURE SUPPLY - MOTOR PROPELLANT SYSTEM	
- TANK REVISED	+ 3.5
- LINES AND FITTINGS REVISED	+ 1.3
- PURGE ASSEM. ADDED	+ 3.2
FIXED EQUIPMENT GROUP	
GUIDANCE - DOPLER - ACTUAL	- 1.5
GUIDANCE - PRESSURE DRUM REVISED	+ 2.5
FLIGHT TEST EQUIPMENT	
TELEMETERING - ACTUAL WEIGHT	+ 5.9
CAMERA RECOVERY INSTALLATION	+ 4.0
INSTRUMENTS - REVISED	+ 0.8
NOSE 'CHUTE AND EJEC. MECH. REMOVED	-30.0
PRESSURE AND TEMP. PICKUPS - REV.	+13.3

FIG. 2 -- TABLE I WEIGHT STATUS

B. STRUCTURES

1. NOSE

SIDE EJECTION FOR THE NOSE PARACHUTE WAS ABANDONED IN FAVOR OF ANOTHER DESIGN INVOLVING JETTISONING OF THE NOSE CONE. A SEPARATE SMALL PARACHUTE FOR INSTRUMENTATION CAMERA RECOVERY WAS ELIMINATED. THE LOCATOR BEACON WILL BE INCORPORATED IN THE CAMERA CONTAINER. PHOTO-RECORDER INSTRUMENT PANEL, CAMERA, AND BATTERIES HAVE BEEN LOCATED AFT OF THE CHUTE. THE NOSE PARACHUTE WILL BE OF THE MEDIUM WEIGHT RIBBON TYPE FOR WHICH ATTACHMENT FITTINGS HAVE BEEN DESIGNED. A PRIMA-CHORD EXPLOSIVE CHARGE WILL SERVE TO EJECT THE NOSE ASSEMBLY AS RECOMMENDED BY AMC.

NOSE STRUCTURE FOR THE FIRST MISSILE IS ABOUT 70 PERCENT ASSEMBLED.

2. FUSELAGE AND TAIL FINS

WELDING OF TANKS FOR THE FLIGHT TEST MISSILE IS PROGRESSING REASONABLY WELL AS IS STRUCTURE FOR THE ENGINE AND TAIL SECTION. THE FUSELAGE FOR THE FIRST FLIGHT TEST ARTICLE IS ABOUT 25 PERCENT ASSEMBLED.

TWO SETS OF FINS AND MATING STRUCTURE ARE FINISHED. TAB INSTALLATION REMAINS.

3. PLUMBING AND WIRING

PLUMBING FOR ONE MISSILE IS FABRICATED. A VIEW OF A COMPLETED INSTALLATION IS SHOWN IN FIGURE 4.

THE MASTER WIRING DIAGRAM HAS BEEN RELEASED. INDIVIDUAL DYNAMOTORS FOR USE IN A REVISED POWER SUPPLY FOR BOTH STABILIZATION AND TELEMETERING EQUIPMENT HAVE BEEN PROCURED FROM WAA SURPLUS AND PERFORM SATISFACTORILY. THIS REVISED POWER SUPPLY, WITH INDIVIDUAL DYNAMOTORS IN PLACE OF A SINGLE LARGE INVERTER HAVING AN OVER-ALL POWER FACTOR OF LESS THAN 50 PERCENT, REPRESENTS A MAJOR REDUCTION IN CURRENT DRAIN ON THE BATTERY POWER SOURCE. THE SYSTEM IS BEING BUILT UP FOR USE ON THE SECOND FLIGHT TEST MISSILE TO REPLACE THAT PRESENTLY DEVELOPED FOR THE FIRST MISSILE AND WILL BE A MAJOR IMPROVEMENT. A SUBSTANTIAL DOLLAR SAVING IS ALSO

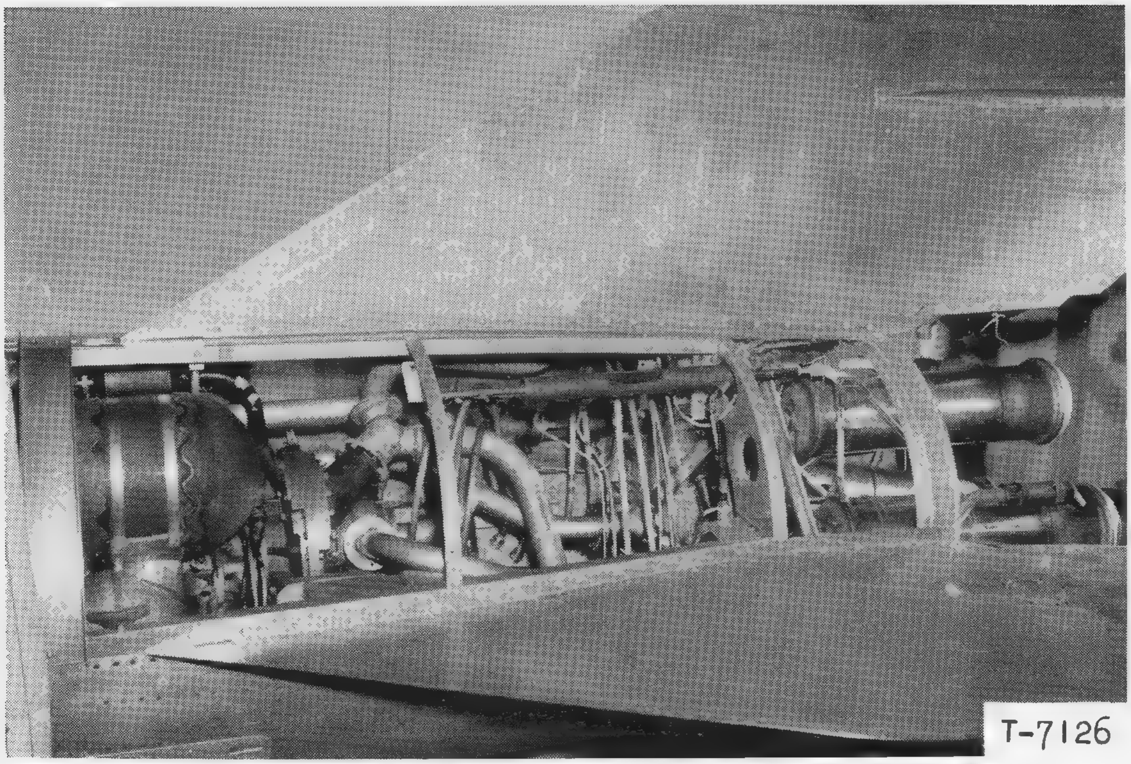

FIG. 4 -- FUEL PLUMBING INSTALLATION

INVOLVED SO LONG AS THE SURPLUS EQUIPMENT LASTS. SPECIAL WILLARD BATTERIES ARE BEING REPLACED BY CONVENTIONAL LEAD-ACID TYPE BATTERIES OF THE SAME WEIGHT AND VOLUME BELIEVED TO BE MORE RELIABLE.

4. TOOLING

EXCEPT FOR MINOR MODIFICATIONS, TOOLING FOR THE FLIGHT TEST VEHICLES IS NEARLY COMPLETE. A JIG PLATE IS NEEDED TO ALIGN THE AFT CENTRAL OUTLET FITTING ON THE ALCOHOL TANK SO AS TO BE CONCENTRIC WITH THE TURBO-PUMP.

C. METALLURGY AND STRESS

REVISED AIRLOADS HAVE BEEN COMPUTED FOR THE PURPOSE OF WRITING A FINAL STRESS ANALYSIS REPORT.

METALLURGICAL PROBLEMS WERE CONFINED TO REWELDING AND RE-HEAT TREATING OF THE FUSELAGE TANKS THAT DID NOT HOLD TEST PRESSURES.

SECTION IV
DYNAMICS ANALYSES

A. AERODYNAMIC INVESTIGATION

A SKETCH OF THE FINAL BASIC CONFIGUARATION OF THE SINGLE STAGE TEST VEHICLE IS PRESENTED BELOW AS FIGURE 5.

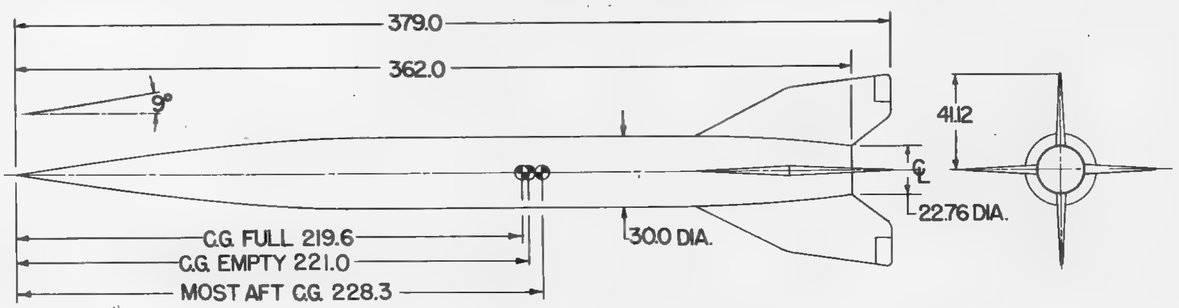

FIG. 5 -- SINGLE STAGE SUPERSONIC TEST VEHICLE

THE FOLLOWING AERO-DYNAMIC INVESTIGATIONS HAVE BEEN MADE.

1. RESULTS OF THE STATIC STABILITY INVESTIGATION ARE PRESENTED IN FIGURE 6. THIS INDICATES AN AMPLE STATIC STABILITY MARGIN OF 8.2 PERCENT BODY LENGTH AT THE CRITICAL CONDITION (M = 4.0) DURING VERTICAL FLIGHT (SEE FIGURE 8).

2. THE MAXIMUM ANGLES OF ATTACK ATTAINABLE IN PITCH AND YAW DURING VERTICAL FLIGHT ARE PRESENTED GRAPHICALLY IN FIGURE 7.

3. PERFORMANCE CHARACTERISTICS IN ASCENDING AND DESCENDING VERTICAL FLIGHT ARE PRESENTED IN FIGURE 8. THE RESULTS INDICATE THAT THE TEST VEHICLE REACHES A MAXIMUM ASCENDING VELOCITY OF 5051 FT/SEC (M = 4.41) AT THE END OF POWERED FLIGHT AND A MAXIMUM DESCENDING VELOCITY OF 5,190 FT/SEC (M = 5.27) WITHOUT THE PARACHUTE OPEN. THE MAXIMUM ALTITUDE ATTAINED IS 521,000 FEET.

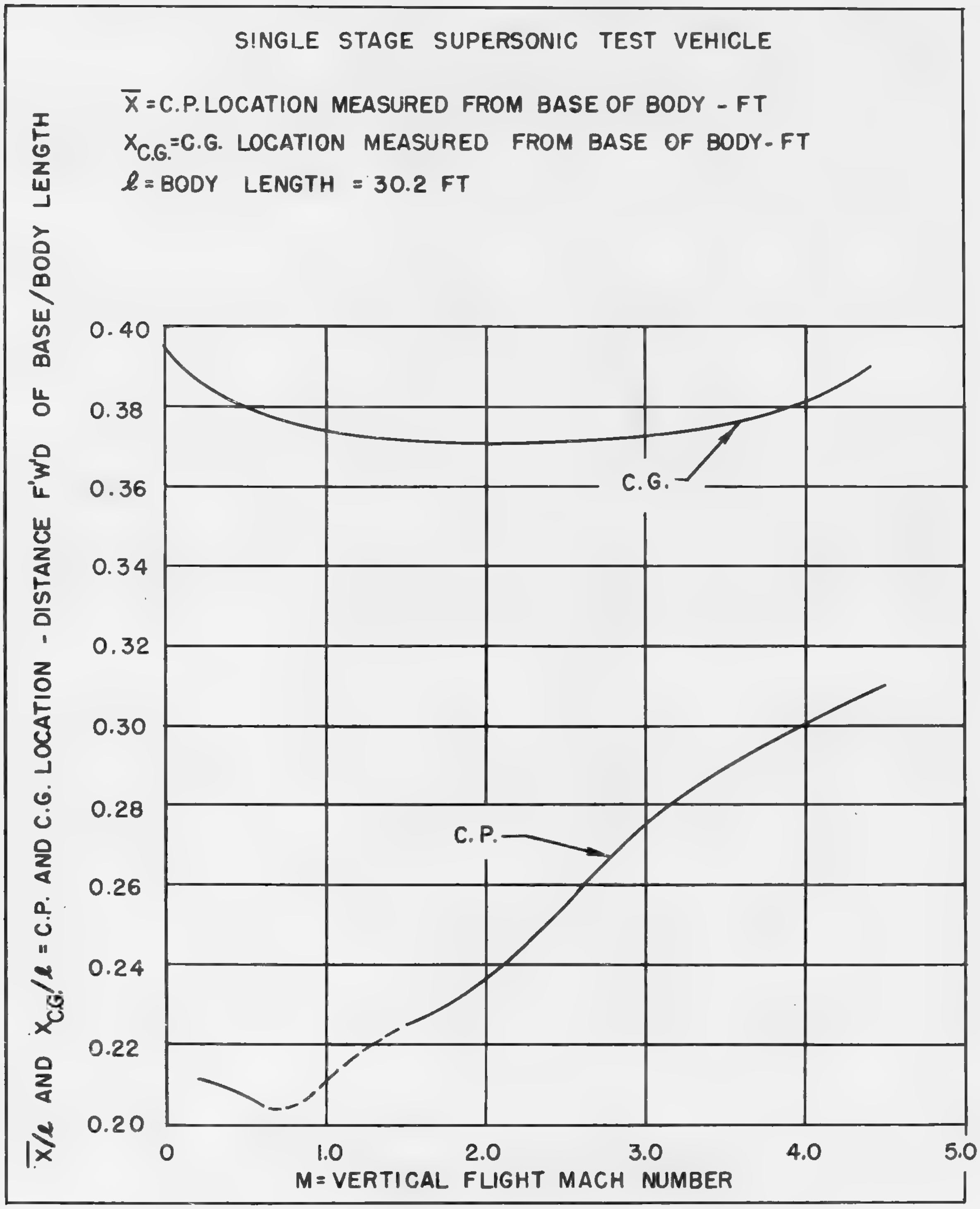

FIG. 6 -- CP AND CG LOCATION AS A FUNCTION OF VERTICAL FLIGHT MACH NUMBER

4. Maximum range was investigated by calculating the range for various initial flight path angles. The test vehicle was assumed to be fired vertically for the first 18 seconds and then turned instantaneously to the flight path angle, θ_0. The maximum range of 174 statute miles was obtained with an initial flight path angle of 75 degrees with respect to the horizontal as shown in Figure 9. The detail flight characteristics for θ_0 = 75 degrees are presented in Figures 10 and 11.

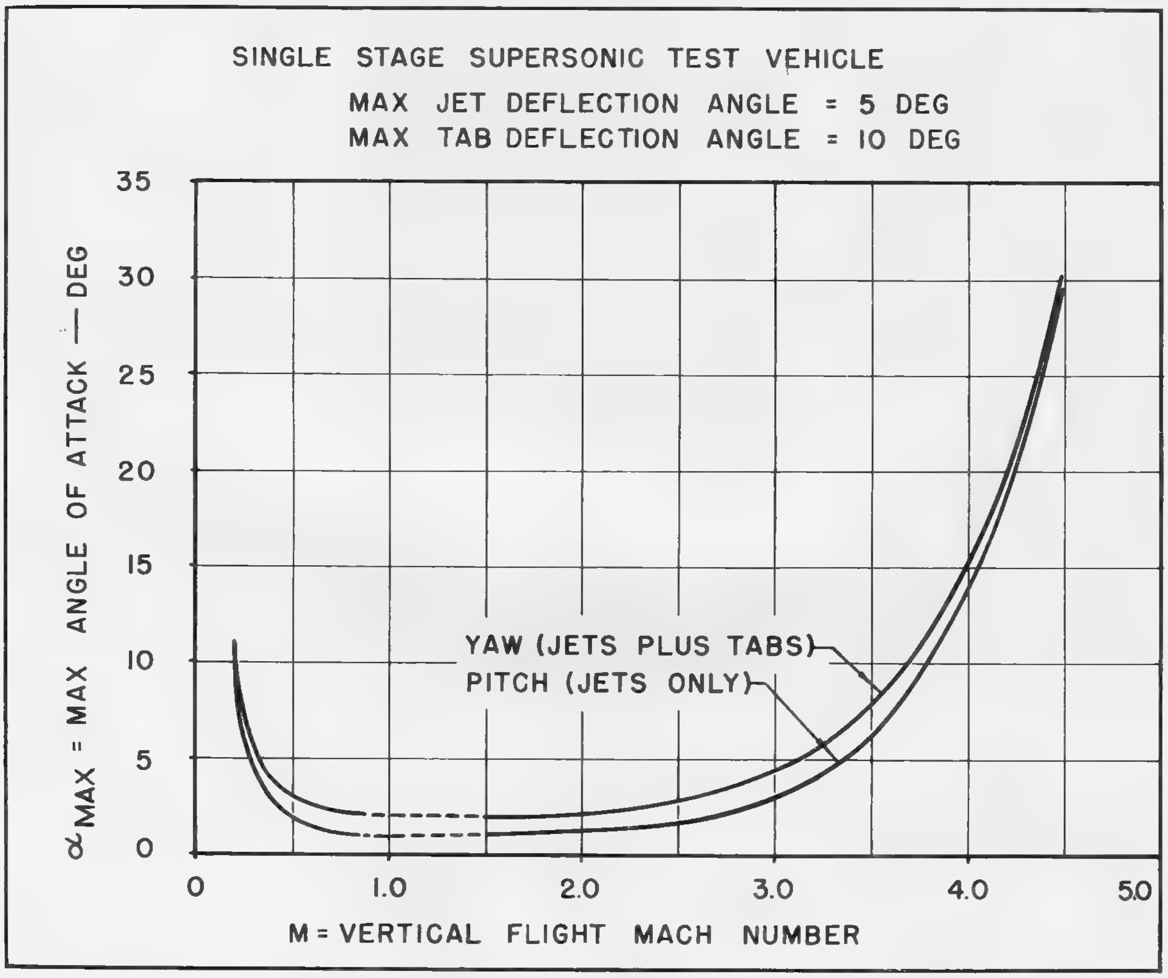

FIG. 7 -- MAXIMUM ANGLE OF ATTACK ATTAINABLE IN PITCH AND YAW WITH MAXIMUM DEFLECTION OF JETS AND TABS

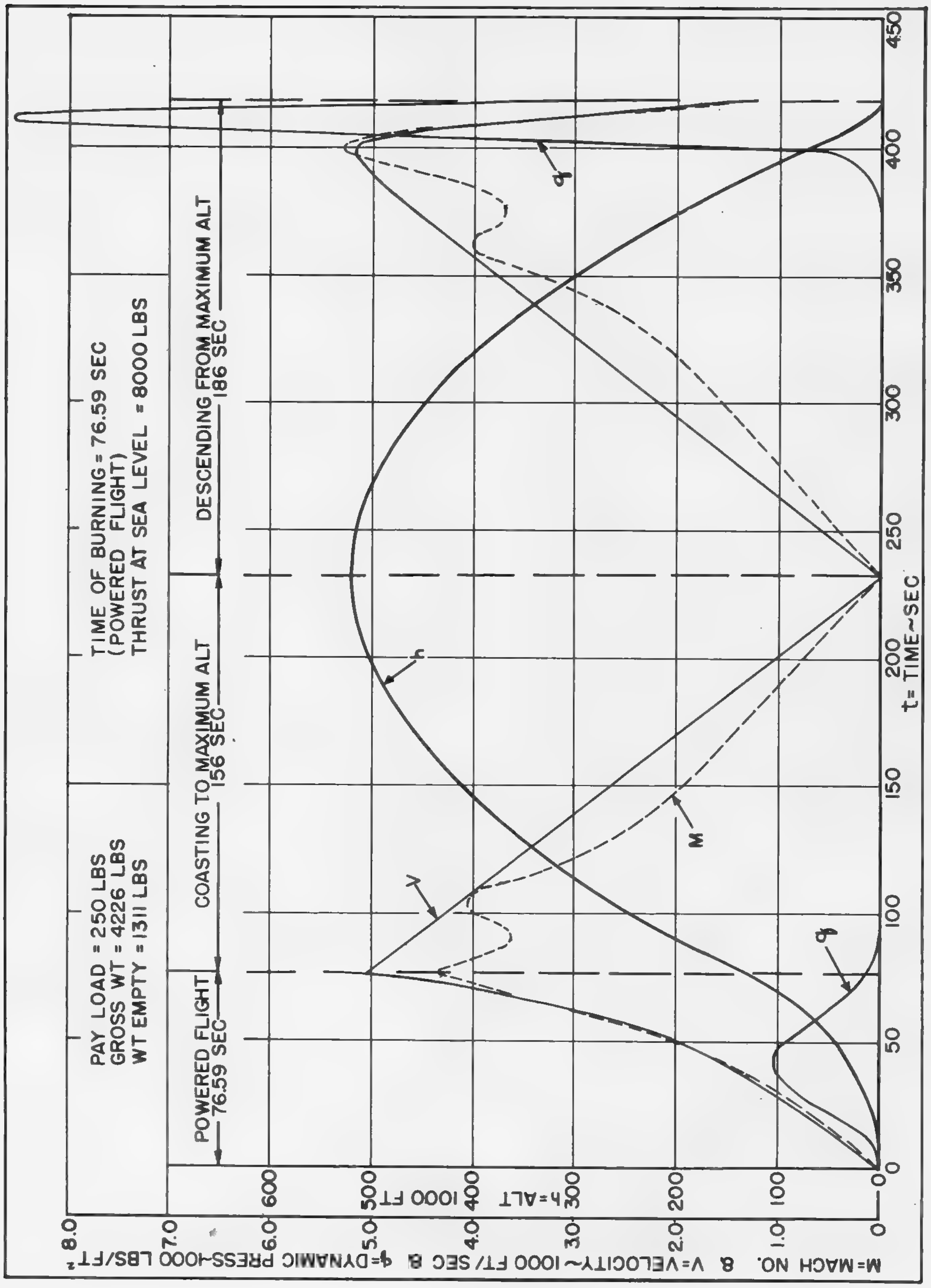

FIG. 8 -- VERTICAL FLIGHT CHARACTERISTICS AS FUNCTIONS OF TIME

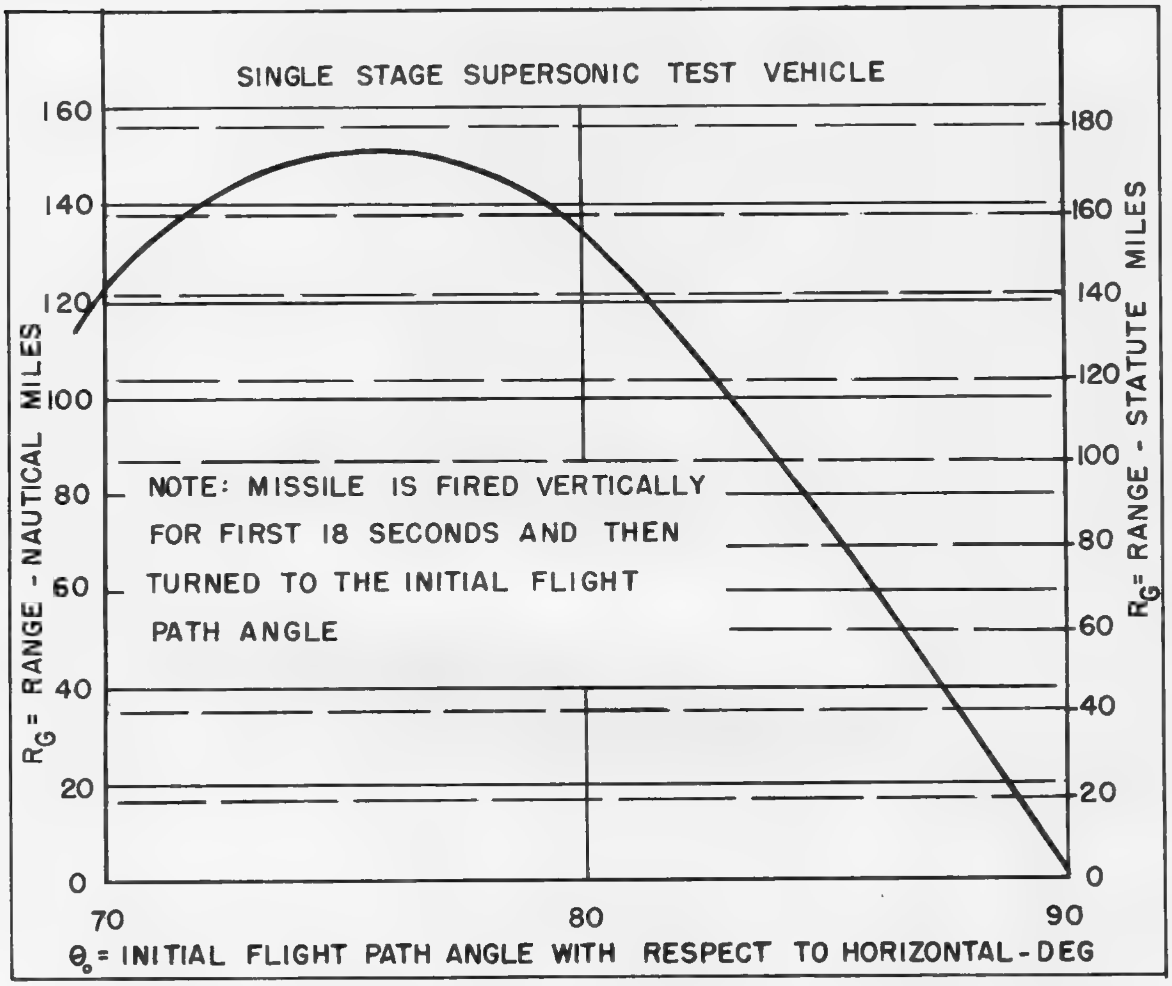

FIG. 9 -- VARIATION OF RANGE WITH INITIAL FLIGHT PATH ANGLE

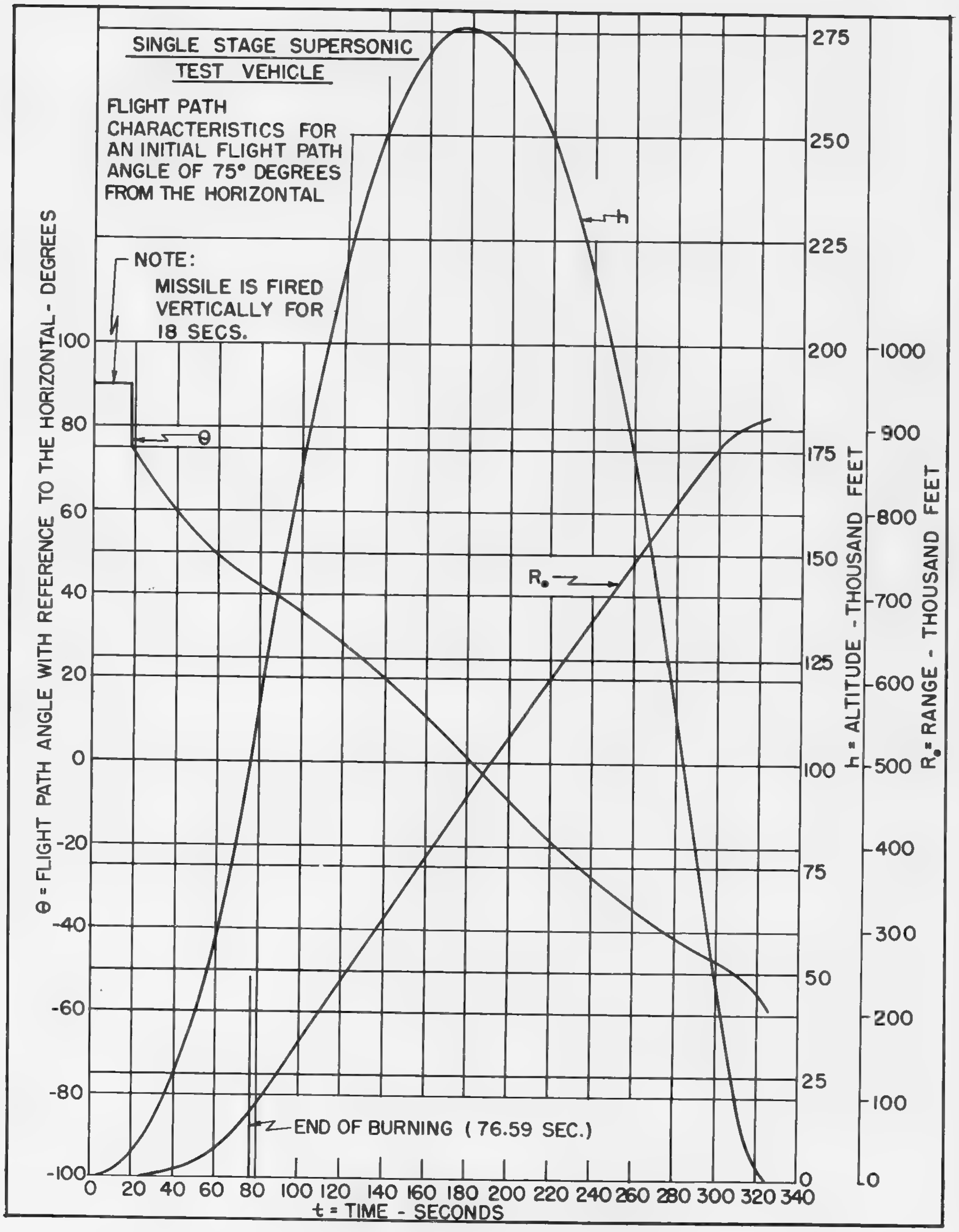

FIG. 10 -- FLIGHT PATH ANGLE, ALTITUDE, AND RANGE AS FUNCTIONS OF TIME

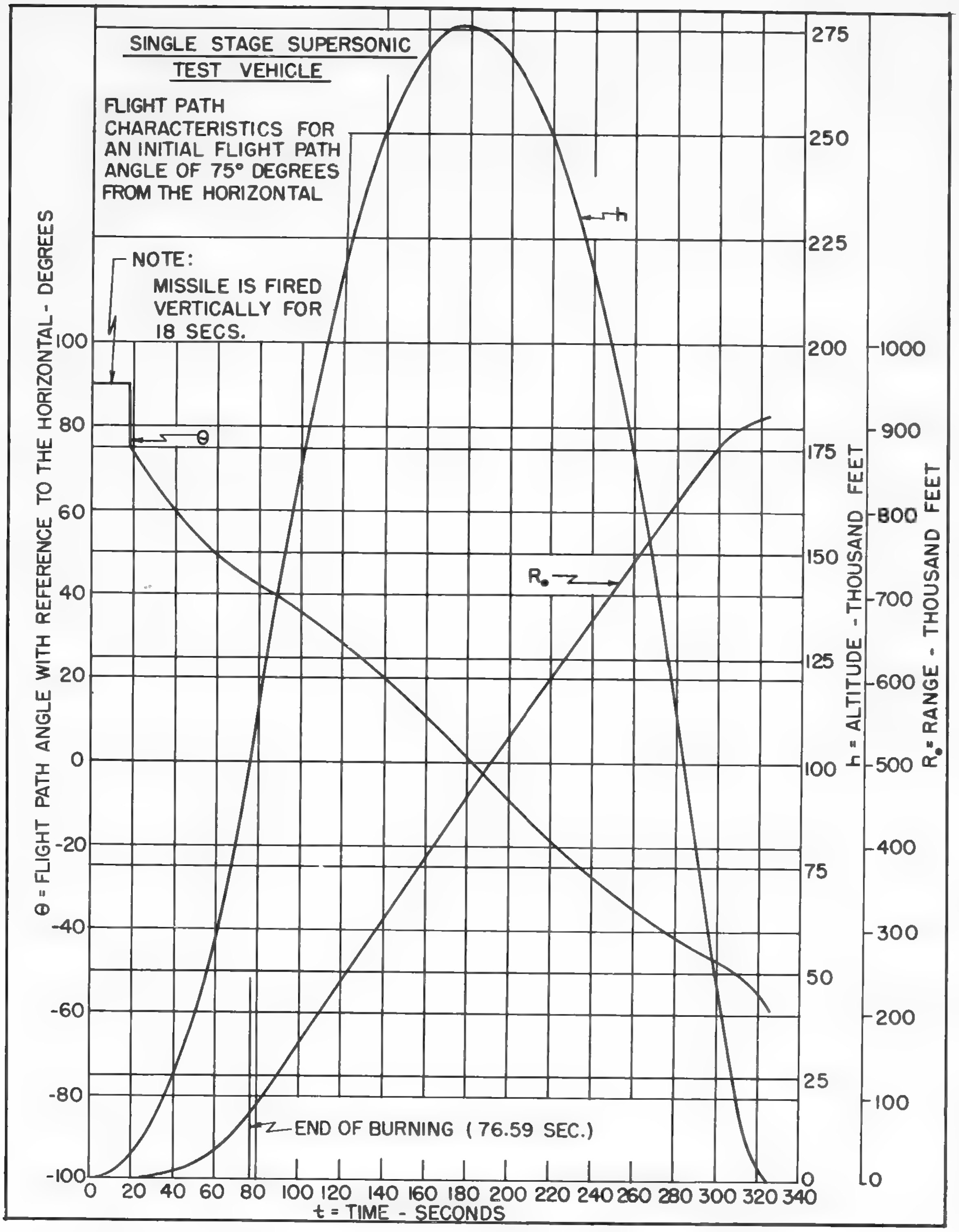

FIG. 10 -- FLIGHT PATH ANGLE, ALTITUDE, AND RANGE AS FUNCTIONS OF TIME

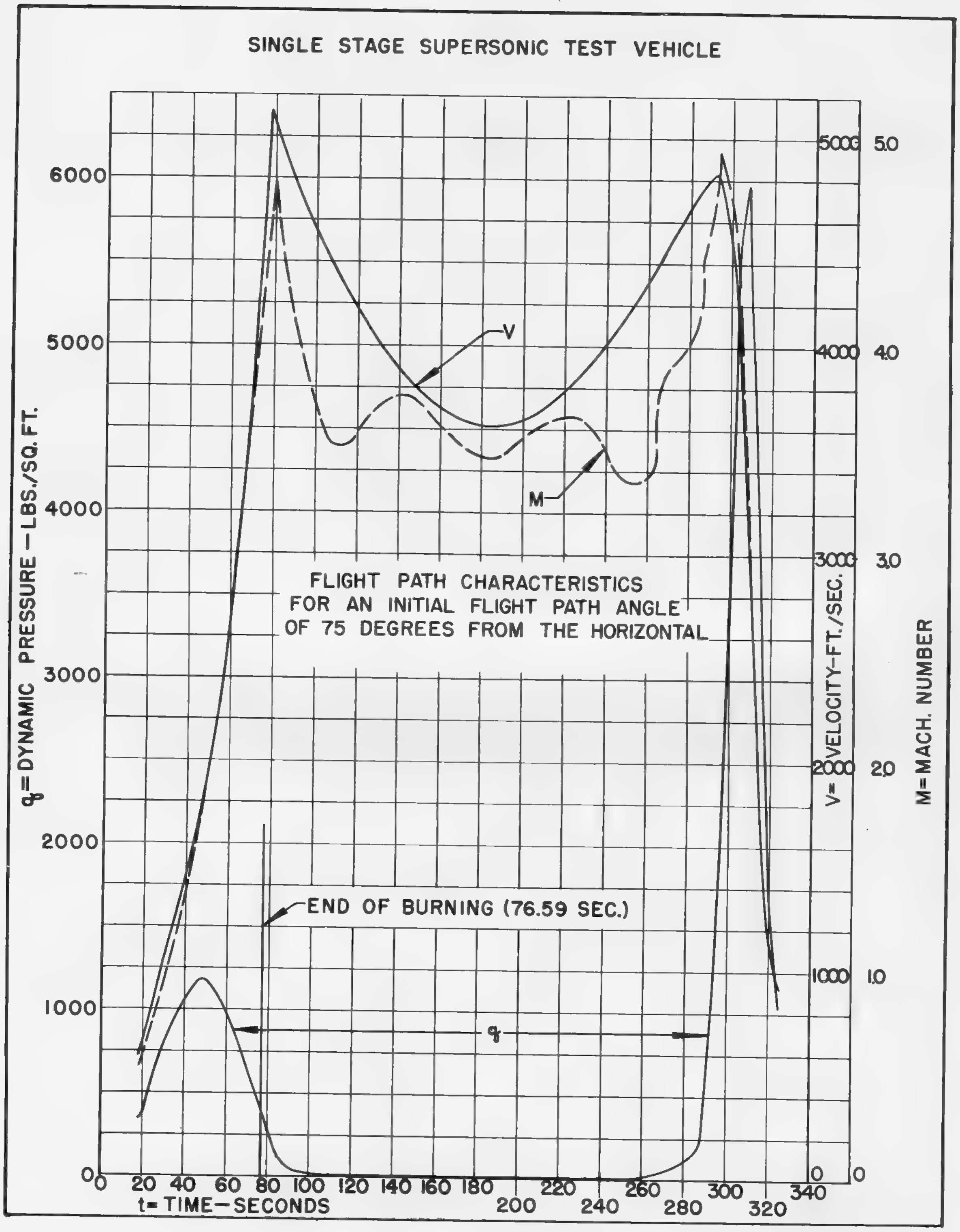

FIG. 11 -- DYNAMIC PRESSURE, VELOCITY, AND MACH NUMBER AS FUNCTIONS OF TIME

B. AZIMUTH GUIDANCE

AN INVESTIGATION HAS BEEN STARTED OF THE BEHAVIOR OF THE MISSILE WHEN AN ATTEMPT IS MADE TO CONTROL ITS FLIGHT PATH. THE PURPOSE OF THE INVESTIGATION IS TO DETERMINE SUITABLE DESIGN CONSTANTS OF PROPORTIONALITY BETWEEN THE GUIDING SIGNAL AND MISSILE RESPONSE.

AXES FIXED ON THE EARTH HAVE BEEN CHOSEN (SEE FIGURE 12), AND MAJOR ASSUMPTIONS ARE AS FOLLOWS:

(1) THE VELOCITY IN THE X DIRECTION IS CONSTANT
(2) ALL ANGLES ARE SMALL
(3) ALL AERODYNAMIC TERMS REMAIN CONSTANT FOR EACH CASE CONSIDERED AT THE VALUE KNOWN AT THE START OF THE PERIOD
(4) PRODUCTS OF ANGLES ARE NEGLIBIBLE

THE EQUATIONS REPRESENTING THE FIVE DEGREES OF FREEDOM THEN BECOME:

$$M_A \ddot{Y} = (T/2)(2\psi - \delta) + K_1 \dot{\psi} + K_2 \beta - K_3 (\psi - \beta) \qquad (1)$$

$$I_Z \ddot{\psi} = (T \ell_2 /2)\, \delta - K_4 \dot{\psi} - K_2 \ell_1 \beta \qquad (2)$$

$$\psi_r = K_5 Y - K_6 \dot{Y} \qquad (3)$$

$$\psi - \beta = (\dot{Y} - \dot{Y}_W)/\dot{X} \qquad (4)$$

$$\delta = K_7 (\psi - \psi_r) + K_8 \dot{\psi} \qquad (5)$$

WHERE M_A = MASS OF THE MISSILE IN SLUGS

T = THRUST IN POUNDS

I_Z = MOMENT OF INERTIA IN YAW IN SLUG FT^2

ℓ_1 = DISTANCE FROM CG TO CP

ℓ_2 = DISTANCE FROM CG TO JET PIVOT POINT

$K_1 = (L/V) \left[(V/L)(dC_N/d\dot{\psi}) \right] q S_B$

$K_2 = (dC_L/d\alpha)\, q S_B$

$K_4 = (L^2/V)(dC_M/d\dot{\psi})\, q S_B$

K_5 THRU K_8 ARE DEFINED BY EQUATIONS (3) AND (5)

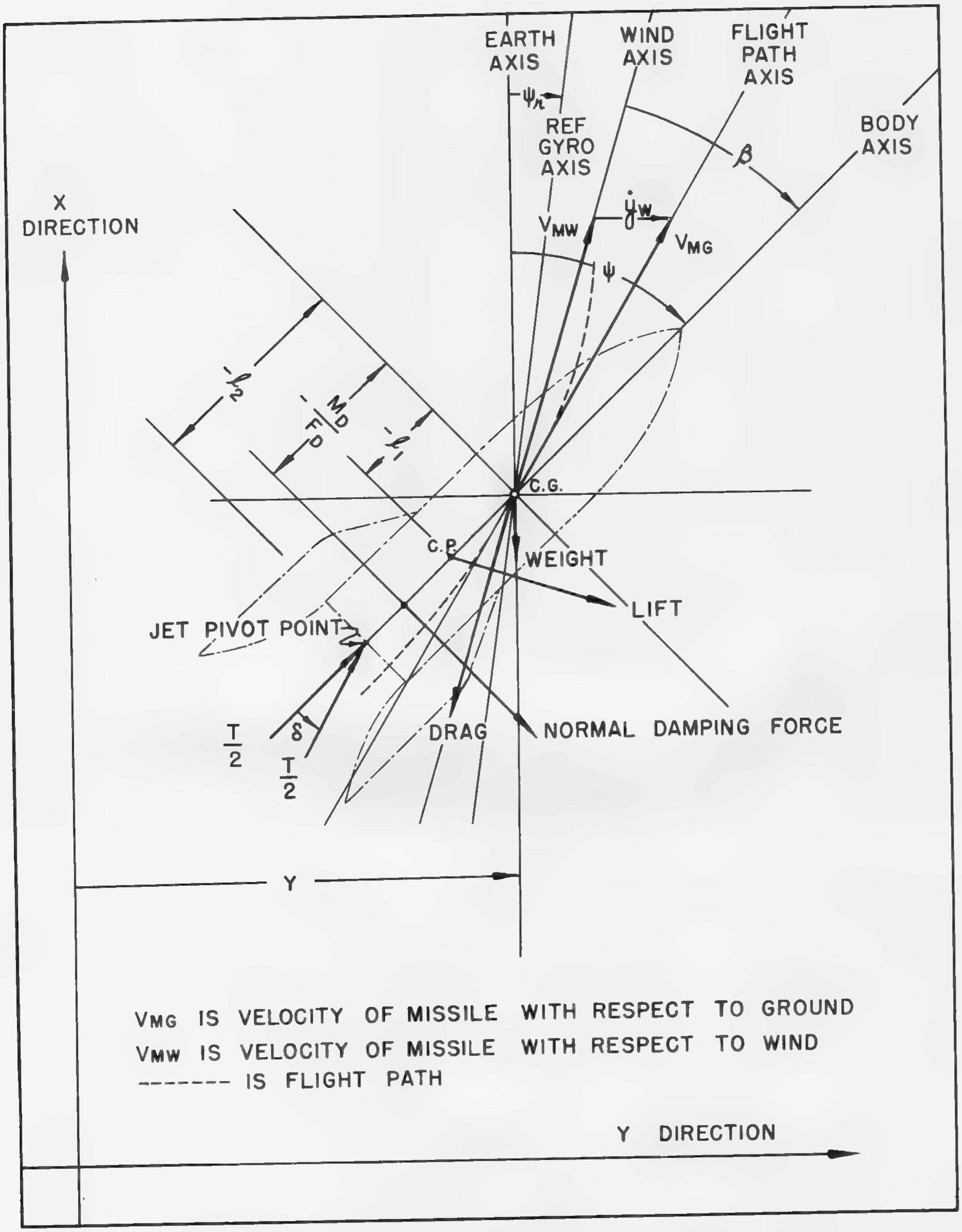

FIG. 12 -- REFERENCE AXES FOR AZIMUTH GUIDANCE INVESTIGATION

L = MISSILE LENGTH IN FEET

V = VELOCITY ALONG THE FLIGHT PATH IN FT/SEC

$dC_N/d\dot{\psi}$ = NORMAL DAMPING FORCE COEFFICIENT PER UNIT YAWING VELOCITY

$dC_M/d\dot{\psi}$ = DAMPING MOMENT COEFFICIENT PER UNIT YAWING VELOCITY

q = DYNAMIC PRESSURE IN LB/FT^2

S_B = MAXIMUM CROSS-SECTIONAL AREA OF THE BODY

ψ_r = ANGLE BETWEEN REFERENCE GYRO AND X AXIS

$\dot{Y}_W$ = VELOCITY OF THE WIND WITH RESPECT TO THE GROUND IN FT/SEC

$K_3 = C_{D_0} \; q S_B$

δ = JET DEFLECTION

THE SERVO EQUATION (5) HAS BEEN SIMPLIFIED TO EXCLUDE THE $\dot{\delta}$ AND $\int(\psi - \psi_r)$ TERMS AS A FIRST APPROXIMATION.

IDEALLY, Y AND $\dot{Y}$ SHOULD BE ZERO AT FUEL SHUTOFF. IT IS MORE IMPORTANT THAT $\dot{Y}$ BE KEPT SMALLER THAN Y; HOWEVER, SINCE DURING THE FREE FALL STAGE OF THE TRAJECTORY A SMALL SIDEWISE VELOCITY COULD PRODUCE A LARGE DISPLACEMENT. THEREFORE, IT HAS BEEN OUR OBJECTIVE TO HOLD $\dot{Y}$ TO A MINIMUM.

SOLVING EQUATIONS (1) THRU (5) SIMULTANEOUSLY, WE ARRIVE AT AN EQUATION FOR Y, WHICH IS:

$$Y = C_1 e^{\lambda_1 t} + C_2 e^{\lambda_2 t} + C_3 e^{\alpha t} \sin(\beta t - \phi) + C_4$$

WHERE $\lambda_1, \lambda_2, \alpha, \beta$, AND C_4 ARE KNOWN

A SOLUTION FOR C_1, C_2, C_3, AND ϕ MAY BE OBTAINED BY DIFFERENTIATING THIS EXPRESSION THREE TIMES AND SUBSTITUTING INITIAL CONDITIONS OBTAINED FROM EQUATIONS (1) THROUGH (5). THEN BY PUTTING $\ddot{Y} = 0$ THE MAXIMUM VALUE OF $\dot{Y}$ MAY BE DETERMINED AND QUANTITATIVELY ADJUDGED.

THREE CASES HAVE BEEN CHOSEN FOR ANALYSIS. IN EACH, IT IS ASSUMED THAT THE MISSILE IS FLYING WITH $Y = \dot{Y} = \psi = \dot{\psi} = 0$ (AT $t = 0$). THE MISSILE SUDDENLY STRIKES A CROSS WIND OF 100 FT/SEC AND ITS ACTION IS STUDIED FROM THAT POINT ON. CASE I IS AT $M = 3.0$ WHERE THERE ARE STILL SEVERAL SECONDS LEFT FOR CORRECTION BEFORE SHUTOFF. CASE II IS IMMEDIATELY BEFORE SHUTOFF ($M = 4.41$). HERE IT IS FURTHER ASSUMED THAT JUST ENOUGH FUEL REMAINS TO ALLOW $\dot{Y}$ TO REACH ITS FIRST MAXIMUM. CASE III IS IMMEDIATELY AFTER SHUTOFF ($M = 4.41$). THIS LATTER CASE WAS CHOSEN TO AID IN THE SELECTION OF A GAUGE BY WHICH WE MIGHT MEASURE THE SUCCESS OF CONTROL*. THE PROCESS NOW BEING CLEAR, IT IS NECESSARY ONLY TO CHOOSE SUCCESSIVE VALUES OF K_5 AND K_6 (K_7 AND K_8 BEING DETERMINED PRIMARILY BY STABILIZATION REQUIREMENTS) UNTIL OUR REQUIREMENTS ARE MET. ON THIS BASIS, CALCULATIONS ARE IN PROGRESS.

C. FLIGHT PATH CONTROL OF TEST VEHICLE

1. Controlled Flight Path

THE TEST FLIGHT PROCEDURE TO BE FOLLOWED BY THE FIRST TEST VEHICLE TO BE FIRED AS OUTLINED IN REFERENCE 11, PAGE 61, HAS BEEN MODIFIED. AFTER 55 SECONDS OF UNDISTURBED VERTICAL FLIGHT, THE PITCH JETS ARE FULLY DEFLECTED (5 DEGREES) AND HELD UNTIL FUEL SHUTOFF. THE SAME STEP-BY-STEP INTEGRATION METHOD USED BEFORE IS BEING APPLIED. NO RESULTS ARE AVAILABLE AT THIS TIME AS THE CALCULATIONS HAVE JUST BEGUN.

2. Effect of Controls

IN LINE WITH THE ANALYSIS ON MAXIMUM CROSS-WIND VELOCITY THAT WILL PERMIT A VERTICAL FLIGHT PATH AS REPORTED IN REFERENCE 11, PAGE 61, A SIMILAR ANALYSIS WAS CONDUCTED TO DETERMINE ABILITY OF THE MISSILE TO RECOVER TO THE VERTICAL AFTER A CROSS WIND DISTURBANCE. ASSUMING "WEATHER VANE" STABILITY AND VERTICAL FLIGHT AT THE INSTANT THE CROSS WIND IS MET, IT WAS FOUND THAT THE MISSILE CAN RECOVER TO THE VERTICAL FROM EFFECTS OF A 50 FT/SEC CROSS WIND AT ALL MACH NUMBERS EXCEPT PERHAPS TRANSONIC. WHEN $0.8 < M < 1.5$, NO PREDICTIONS CAN BE MADE.

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* BEING INDEPENDENT OF SERVO AND GUIDANCE CONSTANTS, CASE III WAS CALCULATED BUT ONCE.

BASIS FOR THIS STATEMENT LIES IN COMPARISON OF THE ANGLES θ AND ξ

WHERE $\theta' = \Delta\alpha - \alpha$

$\xi = \tan^{-1} (\Sigma F_Y / \Sigma F_X)$

$\Delta\alpha = \tan^{-1} (v/V)$

α = MAXIMUM ATTAINABLE ANGLE OF ATTACK

ΣF_Y = SUM OF THE FORCES IN THE Y (NORMAL) DIRECTION

ΣF_X = SUM OF THE FORCES IN THE X (FLIGHT PATH) DIRECTION

v = VELOCITY OF THE CROSS WIND

V = VELOCITY OF THE MISSILE

WHEN $\theta' < \xi$ MISSILE WILL NOT RECOVER

$\theta' = \xi$ MISSILE WILL CONTINUE IN STRAIGHT LINE AT CONSTANT ANGLE θ'

$\theta' > \xi$ MISSILE WILL RECOVER

$\theta' < 0$ FULL JET DEFLECTION IS NOT REQUIRED FOR RECOVERY

D. ROLL STABILIZATION ANALYSIS

A TRANSFER FUNCTION ANALYSIS OF THE ROLL STABILIZATION SYSTEM WAS BEGUN TAKING INTO CONSIDERATION TIME LAGS OR PHASE SHIFT AS WELL AS CHANGES IN GAIN IN THE VARIOUS COMPONENTS AS DETERMINED BY LABORATORY TESTS AND ANALYTICAL STUDIES ON THE INDIVIDUAL COMPONENTS. CALCULATION OF OPTIMUM VALUES OF THE OVERALL SERVO CONSTANTS WAS THEN MADE THROUGHOUT THE REGION OF POWERED FLIGHT. OPTIMUM VALUES AT TAKEOFF WERE CHOSEN FOR THE FIRST TRIAL AND THE SYSTEM RESPONSE COMPUTED AT OTHER POINTS ALONG A VERTICAL FLIGHT PATH. THESE PROVED TO MAKE THE SYSTEM UNSTABLE IN THE TRANSONIC REGION; HENCE, NEW CONSTANTS WERE CHOSEN WHICH WERE MORE NEARLY OPTIMUM IN THAT REGION. THE SYSTEM THEN PROVED TO BE STABLE DURING THE ENTIRE POWERED FLIGHT ALTHOUGH TENDING TOWARD INSTABILITY NEAR FUEL SHUTOFF. FURTHER REFINEMENT IN RESPONSE WILL BE MADE BY SUCCEEDING SELECTIONS OF THESE OVERALL SERVO CONSTANTS.

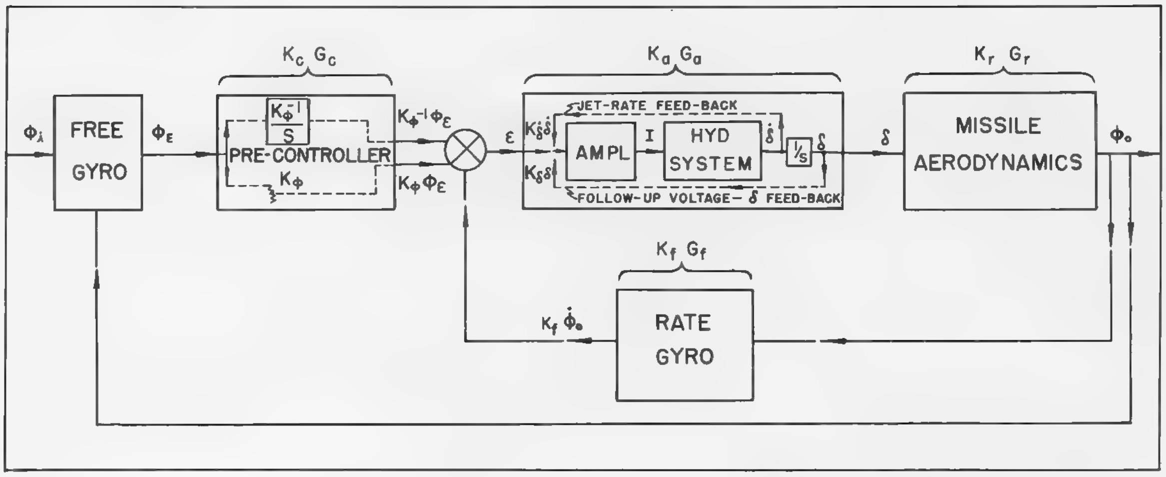

FIG. 13 -- BLOCK DIAGRAM OF ROLL STABILIZATION SYSTEM

THE PRESENT STABILIZATION SYSTEM IS PRESENTED IN THE BLOCK DIAGRAM IN FIGURE 13, WHERE K_A G_A, K_C G_C, ETC, REPRESENT THE TRANSFER FUNCTIONS (I.E., OUTPUT/INPUT) OF THE INDIVIDUAL COMPONENTS. (REFERENCE A). A STUDY OF THE OVERALL TRANSFER FUNCTION KG (RATIO OF THE ERROR SIGNAL ϕ_e TO THE ACTUAL ROLL ATTITUDE ϕ_0) ALLOWS DETERMINATION OF PERFORMANCE AND STABILITY OF THE SYSTEM. THE OVERALL TRANSFER FUNCTION KG, USING LAPLACE TRANSFORMATION NOTATION, IS:

$$KG = L\phi_0/L\phi_i = \left[(K_C\ G_C)(K_A\ G_A)\ (K_R\ G_R)\right] / \left[1 + (K_A\ G_A)(K_R\ G_R)(K_F\ G_F)\right]$$

EXPANDING, THIS BECOMES:

$$L\phi_0/L\phi_e = KG = K_0\left[\mu^2\ (\mu^2 + T_S\ \mu + 1) + K_M\ \mu\ (\mu^2 + 2T_S\ \mu + 1) + (K_D\ /(R^2\mu^2 + 2T_F\ R\mu\ - 1))\right]^{-1}$$

WHERE

$\mu = S/\omega_S$

$R = \omega_S/\omega_F$

T_S = RATIO OF ACTUAL DAMPING TO CRITICAL DAMPING OF THE HYDRAULIC SYSTEM

T_F = RATIO OF ACTUAL DAMPING TO CRITICAL DAMPING OF THE RATE GYRO

ω_S = NATURAL FREQUENCY OF HYDRAULIC SYSTEM

ω_F = NATURAL FREQUENCY OF RATE GYRO

$K_0 = (K\phi/I) \quad (K_A/\omega_S^2) \; L_\delta$

$K_M = 1/T_S \, \omega_S = 1/I \; (L_p/\omega_S)$

$K_D = K_F/I \quad (K_A/\omega_S) \; L_\delta$

I = MOMENT OF INERTIA IN ROLL

L_δ = ROLLING MOMENT DUE TO JET AND TRIM TAB DEFLECTION

$L_p = \partial L/\partial P$ = ROLLING MOMENT DUE TO ROLLING VELOCITY

S = LAPLACE VARIABLE, d/dt

K_M, R, K_0, AND K_D ARE THE CONSTANTS OF THE STABILIZATION SERVO SYSTEM WHICH DETERMINE THE OVERALL ROLL PERFORMANCE. THEY ARE NOT AFFECTED BY THE ERROR SIGNAL NOR BY ANY SYSTEM DISTURBANCES.

THE FACTORS WHICH CHANGE THESE FOUR PARAMETERS IN FLIGHT ARE SUMMARIZED BELOW.

(1) VARIATION IN AERODYNAMIC DAMPING WITH MACH NUMBER AND ALTITUDE = $\partial L/\partial P$

(2) VARIATION OF JET MOTOR THRUST WITH ALTITUDE

(3) VARIATION OF ROLLING MOMENT DUE TO TABS $\partial L_\delta/\partial \delta_t$

(4) VARIATION IN NATURAL FREQUENCY OF THE HYDRAULIC SYSTEM DUE TO CHANGES IN TAB HINGE MOMENT WITH MACH NUMBER AND ALTITUDE

(5) VARIATION IN LOAD ON THE HYDRAULIC SYSTEM DUE TO CHANGE IN TAB HINGE MOMENT

THESE VARIATIONS HAVE BEEN COMBINED WITH A SET OF THE FIXED PARAMETERS OF THE SYSTEM TO GIVE THE ACTUAL VARIATION OF K_M, R, K_0, AND K_D DURING VERTICAL FLIGHT. THE FIXED PARAMETERS (K_ϕ, K_δ, K_F, AND ω_F (SEE FIGURE 13) WERE CHOSEN TO GIVE OPTIMUM PERFORMANCE AT TAKEOFF (CASE I). THE ACTUAL VARIATION OF K_M, R, K_0, AND K_D DURING VERTICAL FLIGHT FOR CASE I IS SHOWN IN FIGURE 14. NYQUIST DIAGRAMS PLOTTED FROM KG FOR VARIOUS TIMES OF FLIGHT SHOWED THAT THE CONSTANTS OF CASE I CAUSED THE SYSTEM TO BE UNSTABLE AT $t = 24.5$ AND $t = 30$.

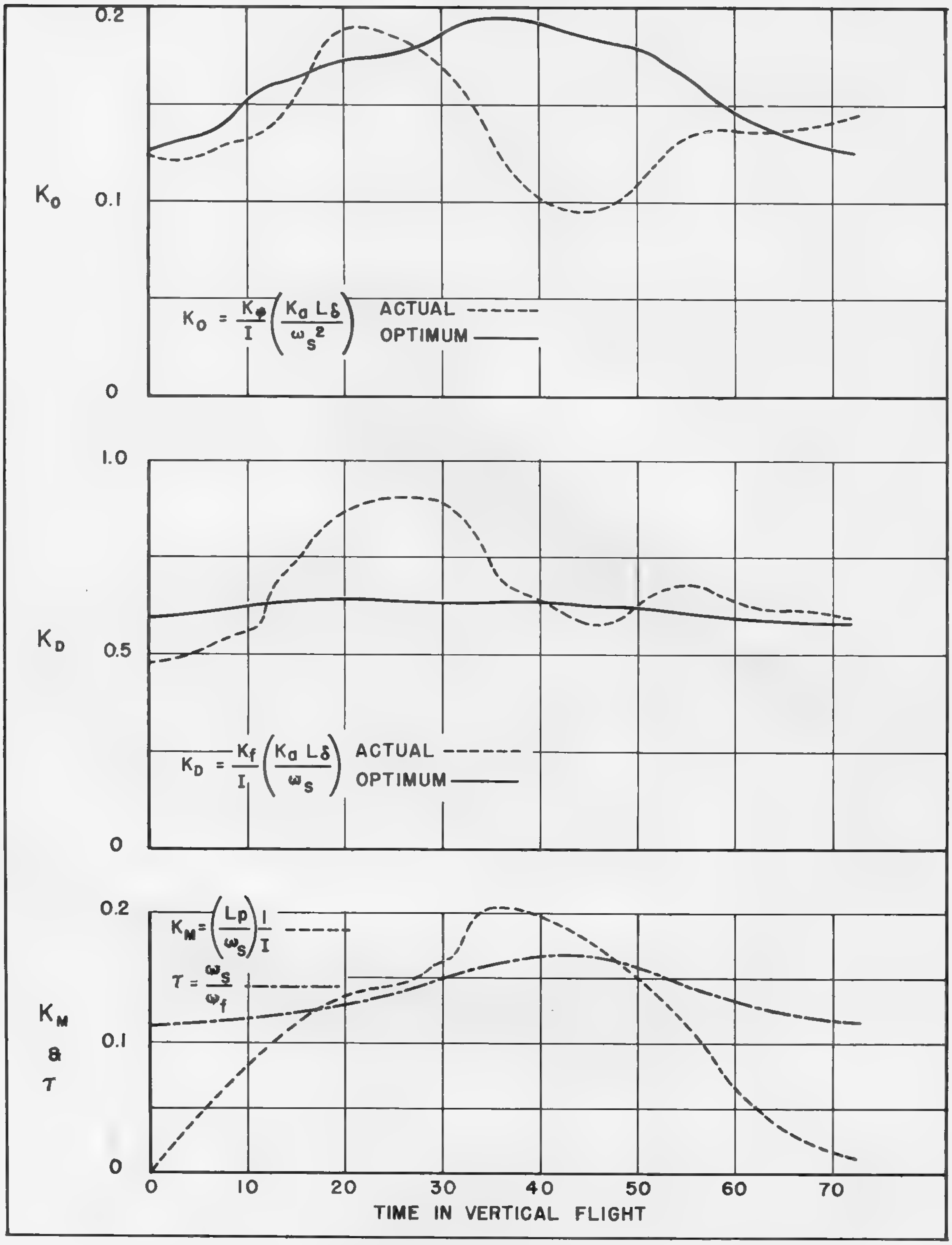

FIG. 14 -- SERVO PARAMETERS IN FLIGHT (CASE I)

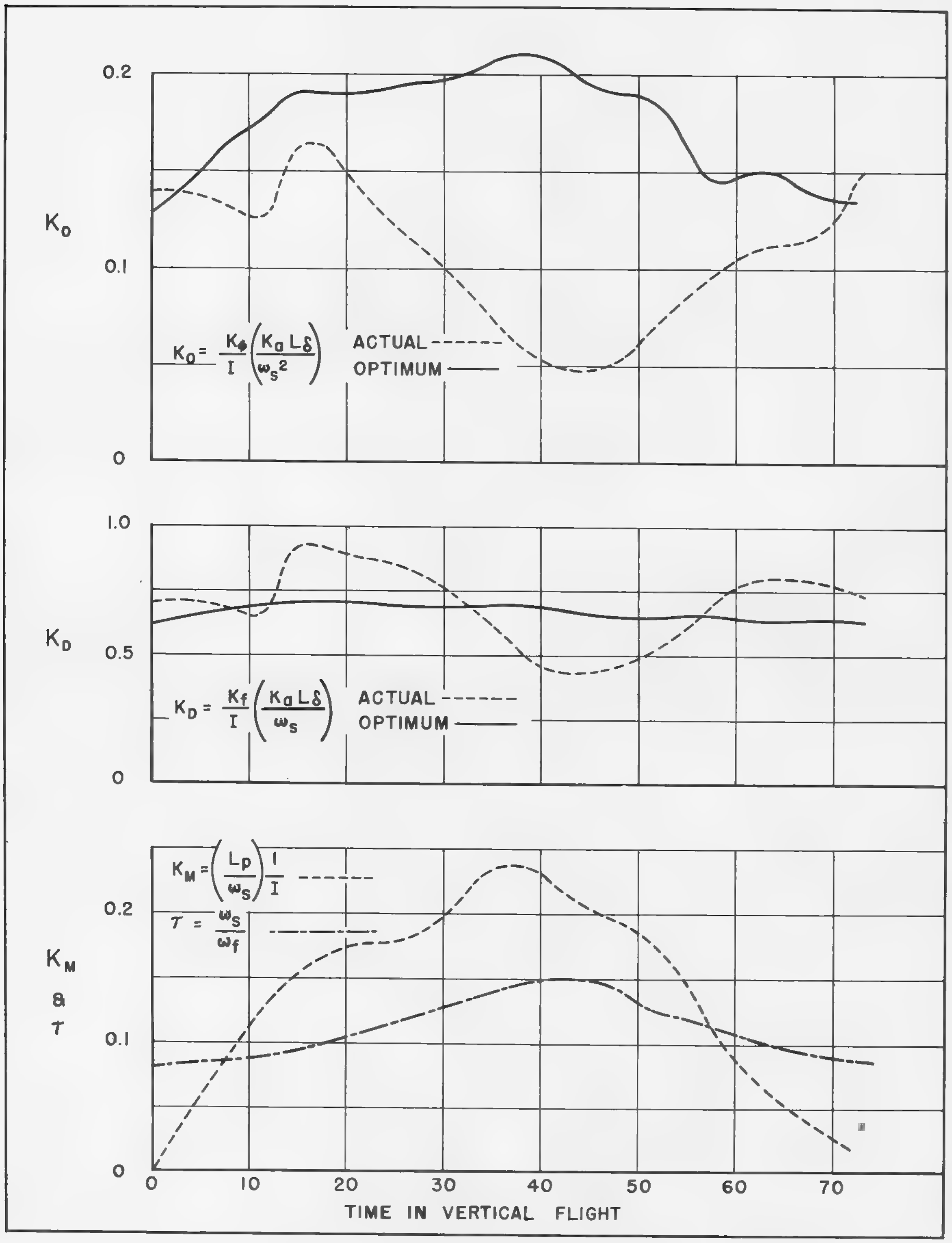

FIG. 15 -- SERVO PARAMETERS IN FLIGHT (CASE II)

A second set of fixed parameters was then chosen (Case II) and the variation of K_M, R, K_O, and K_D calculated for various times during vertical flight as shown in Figure 15. Nyquist diagrams plotted for Case II from KG for various times of flight showed no instability, but the response of the system was far from optimum near the end of powered flight. Further investigations should lead to even more desirable system constants.

E. INVESTIGATION OF LONG-RANGE TRAJECTORIES

Work on this program is now approximately 50 percent complete with work during the July-August period having been centered on computation of permissible errors in magnitude, azimuth angle, and elevation angle of the missile velocity vector and on errors in position (forward, sideward, and upward) for 4000, 4500, 5000, 5500, and 6000 mile elliptical arcs striking the earth at angles of 10, 15, 20, 25, and 30 degrees.

1. Time and Position Errors

Computation of the errors in time and position on a non-rotating earth due to errors in elevation angle, azimuth angle, and the magnitude of velocity have been completed. A method is indicated whereby the above error information can be used to compute errors in position when firing in any direction between any two given points on a rotating earth.

2. Range Angle Calculations

A new expression for range angle in terms of geocentric distance, elevation angle, velocity at fuel shut-off point, and a gravitational constant at the earth's surface was developed, and computation has been completed for graphing these results. Fuel shut-off point will range from 40 to 200 miles elevation (shut-off elevation angles at 10 to 30 degrees) with ranges of 4000 to 6000 miles. Expressions for permissible errors in elevation angle and velocity at shut-off elevations are still being developed.

3. Error-At-The-Target Investigation

Work has been done relative to permissible errors in striking angle, velocity, and azimuth angle. Computation of permissible errors for a one mile miss at the target on a non-rotating earth has been completed and final graphs of the results are under preparation. Effects of combined errors in

VELOCITY AND STRIKING ANGLE ON THE MAGNITUDE OF THE MISS AT THE TARGET ARE ALSO BEING INVESTIGATED. A GRAPH HAS BEEN PREPARED SHOWING THE STRIKING VELOCITY AT THE EARTH'S SURFACE FOR VARIOUS RANGES AND STRIKING ANGLES. A METHOD IS BEING DEVELOPED FOR UTILIZATION OF THESE GRAPHS WITH RESPECT TO VELOCITY AND ELEVATION ANGLE CHANGES AT FUEL SHUT-OFF FOR PERMISSIBLE ERROR AT THE TARGET.

4. NEXT PERIOD WORK

ORGANIZING THE COMPLETED PERTINENT DATA OUT OF THE MASS OF MATERIAL ALREADY DEVELOPED IN THE WIDELY DIVERSIFIED FIELD OF MATHEMATICAL AND COMPUTATIONAL RESEARCH INTO REPORT FORM REMAINS TO BE DONE. IT HAS BEEN FOUND THE FORMULAE OF THE KEPLERIAN ELLIPSE CANNOT BE RELIED UPON FULLY IN THIS NEAR-EARTH REGION AND THE EXACT FORM FOR CORRECTION EXPRESSIONS HAS NOT AS YET BEEN DEDUCED, ALTHOUGH SOME PROGRESS HAS BEEN MADE. HOWEVER, MATHEMATICAL EXPRESSIONS HAVE BEEN DEVELOPED FROM WHICH ALL OF THE REMAINING PROBLEMS MAY BE COMPUTED, AND IT IS EXPECTED THAT COMPLETION OF THE COMPUTATIONS AND GRAPHS ON THIS PROGRAM WILL BE ACCOMPLISHED DURING THE ENSUING BI-MONTHLY WORK PERIOD.

SECTION V
PROPULSION AND FUEL

CAPACITY REQUIREMENTS OF THE TANK PRESSURIZING SYSTEM WERE REANALYZED TO DETERMINE WHETHER THE PRESSURE SUPPLY WOULD BE ADEQUATE TO PREVENT OXYGEN CAVITATION. TAKING INTO ACCOUNT THE EFFECT OF CERTAIN FACTORS WHICH ARE IMPOSSIBLE TO PREDICT, SUCH AS INCREASE OF OXYGEN TEMPERATURE AND RATE OF EVAPORATION, IT WAS INDICATED THAT CAVITATION MIGHT OCCUR IN THE LAST STAGES OF FLIGHT. TO MAKE A MORE SAFE ALLOWANCE FOR THESE UNKNOWNS, THE NITROGEN TANK VOLUME WAS INCREASED RESULTING IN A TANK WEIGHT INCREASE OF 5 POUNDS.

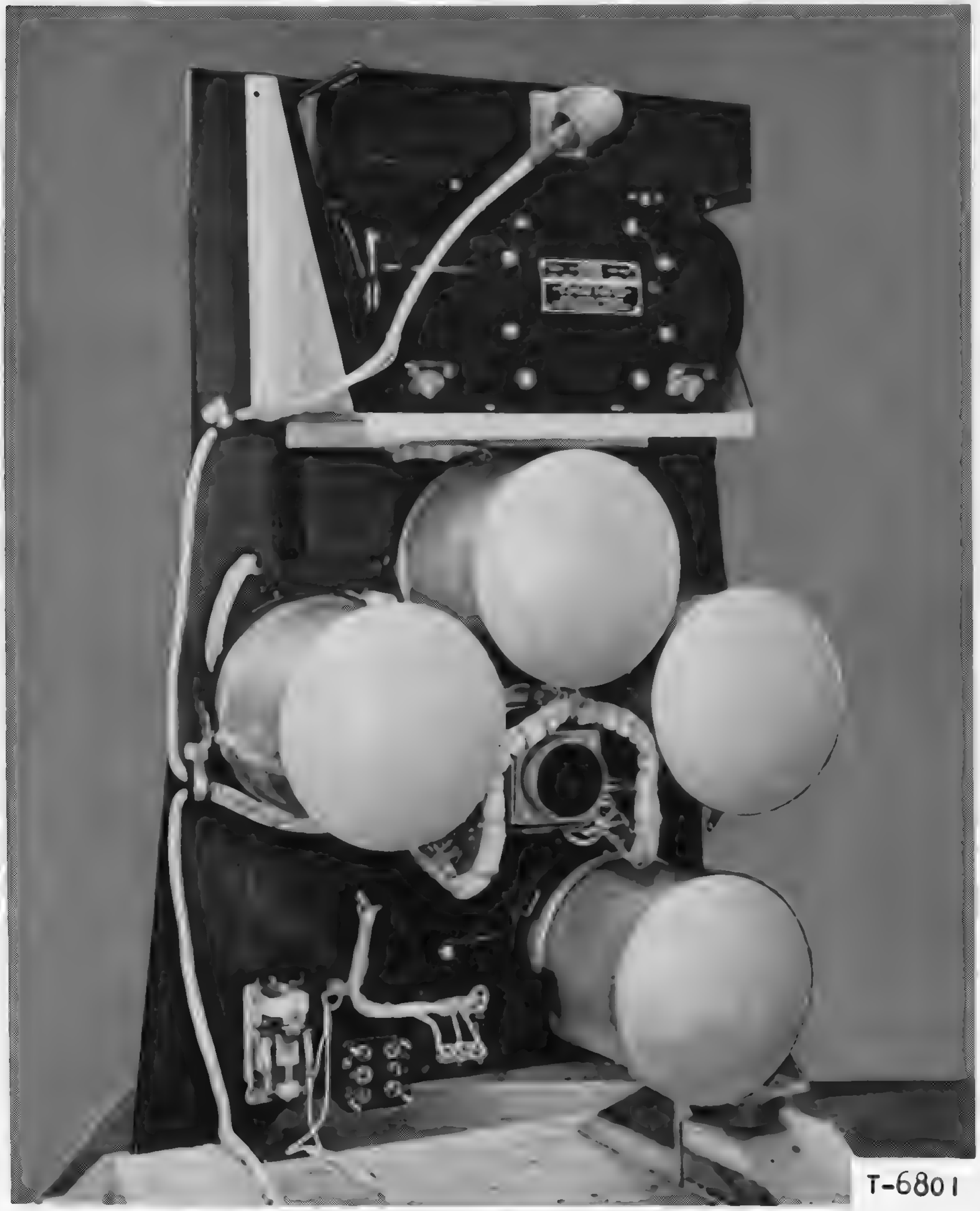

FIG. 16 -- STABILIZATION SYSTEM AMPLIFIER AND GYRO PANEL FOR MISSILE NO. 1

SECTION VI
STABILIZATION AND CONTROLS

A. EQUIPMENT INSTALLATION LAYOUT

A FIVE HOUR OPERATIONAL TEST RUN OF THE AMPLIFIER AND GYRO PANEL ASSEMBLY ON THE SIMULATOR WAS MADE IN ASSOCIATION WITH THE BALANCE OF THE STABILIZATION EQUIPMENT. OPERATION WAS FOUND TO BE VERY SATISFACTORY. THIS ASSEMBLY FIRST WILL BE USED WITHIN THE STATIC TEST MISSILE AND THEREAFTER MOUNTED WITHIN THE LARGER NOSE SECTION OF TEST MISSILE NO. 1. ADDITION OF QUICKLY DETACHABLE MOUNTINGS ON THE PANEL ASSEMBLY FOR THE TELEMETERING GYROS WILL PERMIT READY REMOVAL OF THE GYROS FOR ADJUSTMENT AND CALIBRATION PRIOR TO FLIGHT. THE PANEL ASSEMBLY FOR TEST MISSILE NO. 1 IS SHOWN IN ITS COMPLETED FORM IN FIGURES 16 AND 17.

B. EQUIPMENT DEVELOPMENT

1. AMPLIFIERS

THREE SETS OF STABILIZATION AMPLIFIERS WERE TESTED TO DETERMINE WHETHER HEATING WOULD BE EXCESSIVE, AND TO CHECK FLASH-OVER VOLTAGES AT HIGH ALTITUDES. THE AMPLIFIERS OPERATED UNDER A BELL JAR FOR 15 MINUTES AT 10-MM ABSOLUTE PRESSURE. AFTER APPROXIMATELY 20 MINUTES OF OPERATION, ONE OF THE CAPACITORS FAILED DUE TO EXCESSIVE HEATING. FLASH-OVER FROM PIN TO PIN IN THE PLUG CONNECTOR OCCURRED AT 775 VOLTS DC AT 10-MM ABSOLUTE PRESSURE. FLASH-OVER FROM PIN TO SHELL OCCURRED AT 730 VOLTS DC. SINCE THE MAXIMUM VOLTAGE USED IN ACTUAL OPERATION OF THE AMPLIFIER IS LESS THAN 370 VOLTS, THE TEST PERFORMANCE IS CONSIDERED SATISFACTORY. THE AMPLIFIER CONTAINER SEALS HELD, SO SATISFACTORY PRESSURIZATION HAS BEEN OBTAINED.

2. GYRO DEVELOPMENT

THE G-16 SCHWIEN GYROS HAVE BEEN MODIFIED TO GIVE AN INCREASED RATE SIGNAL OUTPUT. A ONE-DEGREE PER SECOND RATE NOW GIVES A SIGNAL EQUIVALENT TO 0.4 DEGREES OF FREE GYRO DISPLACEMENT. WITH THIS ADJUSTMENT, THE ROLL SYSTEM STABILIZES WITH APPROXIMATELY 0.6 OF CRITICAL DAMPING. PITCH AND YAW ARE ADJUSTED TO APPROXIMATELY 0.8 CRITICAL DAMPING.

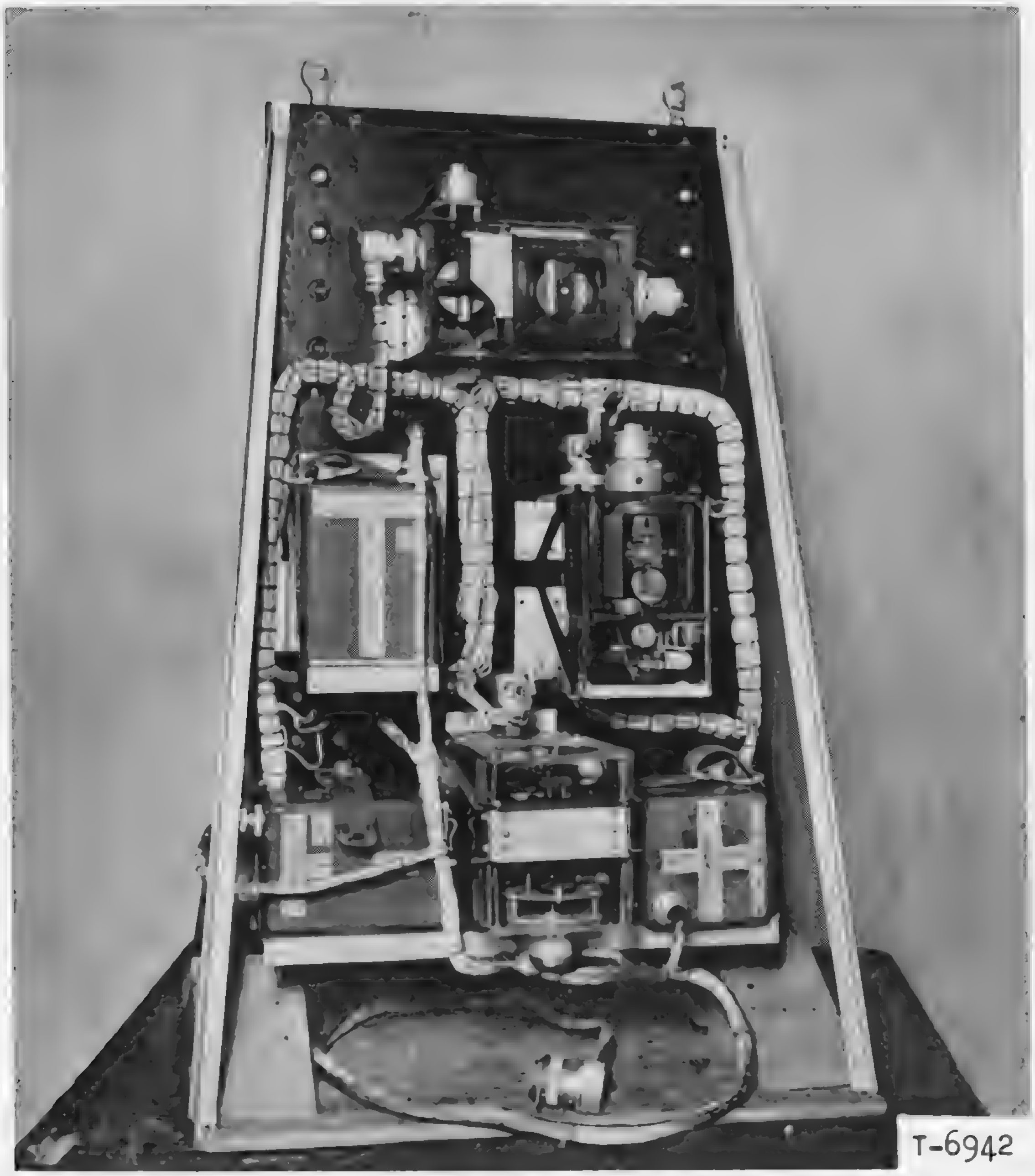

FIG. 17 -- STABILIZATION AND TELEMETERING GYRO PANEL

EXTENSIVE TESTS HAVE BEEN RUN ON THE SIMULATOR TO DETERMINE PROPER ADJUSTMENT OF THE RATE GYRO PICK-OFF RATIO. AS A RESULT, THE RATE SPRINGS HAVE BEEN MADE HEAVIER AND AMPLIFICATION HAS BEEN PUT INTO THE PICK-OFF LINKAGE TO PROVIDE A STRONGER RATE SIGNAL AND STILL RETAIN THE HIGH NATURAL FREQUENCY OF THE GYRO. CALIBRATION AND RE-WORK OF THE GYROS HAVE BEEN STARTED FOR THE FIRST TWO MISSILES SO AS TO INCORPORATE THIS RATE SIGNAL AMPLIFICATION AND HIGHER SPRING GRADIENT.

LAYOUTS ARE BEING MADE FOR MODIFICATIONS OF THE PIONEER TYPE PB-10 AUTOPILOT GYROS WHICH ARE TO BE USED ON THE NUMBER 3 TEST MISSILE. COMMAND CONTROL DRIVE ELEMENTS IN PITCH AND YAW AND INTEGRAL CONTROL DRIVE IN ROLL ARE BEING INCORPORATED IN THE FREE GYROS. IN ADDITION, SERVO-CYLINDER RESPONSE LINKAGE IS BEING ADDED TO THE PICK-OFF AUTOSYN OF THE RATE GYRO.

FABRICATION OF THE COMPONENT PARTS HAVING BEEN ACCOMPLISHED, THE WORK OF ASSEMBLING AND BALANCING THE EXPERIMENTAL FREE-PLATE GYRO IS CONTINUING. FINAL ASSEMBLY AND TESTING OF THE UNIT IS EXPECTED TO BE ACCOMPLISHED DURING THE NEXT REPORT PERIOD.

3. SOLENOID CONTROL VALVES

WORK ON THIS PHASE OF THE PROGRAM INCLUDED ADDITIONAL TESTS ON THE SIMULATOR WHICH WERE RUN AFTER CUTTING DOWN ON THE OVERLAP IN THE PROPORTIONAL CONTROL VALVES. THESE VALVES ARE SPECIALLY DESIGNED, HAVING CHROMIUM PLATED ALUMINUM ALLOY SLIDES MOUNTED DIRECTLY IN AN ALUMINUM ALLOY BLOCK, THEIR PORTS BEING FORMED AS ANNULAR GROOVES IN THE BLOCK WITHOUT UTILIZING AN INTERMEDIATE SLEEVE. OVERLAP IN THESE VALVES WAS REDUCED TO APPROXIMATELY 0.001 INCH IN THE 3/4-INCH DIAMETER ROLL CONTROL VALVE AND APPROXIMATELY 0.0015 INCH IN THE 9/16-INCH DIAMETER PITCH AND YAW VALVES. AN INCREASE OF APPROXIMATELY 20 PERCENT IN THE RATE OF FLOW THROUGH THE VALVES WAS ACCOMPLISHED, WHICH IS EQUIVALENT TO AN INCREASED GAIN IN THE SERVO SYSTEM. IN ADDITION TO THESE IMPROVEMENTS, THE "DEAD SPOT" AT ZERO WHICH CAUSED "HUNTING" WAS ELIMINATED.

TO DATE, NO TROUBLE HAS BEEN ENCOUNTERED FROM CORROSION OR VALVE STICKING DURING THE TWO MONTHS WITH THE VALVE IN SERVICE CONTINUOUSLY AND THE SYSTEM FILLED WITH ALCOHOL.

4. INTEGRAL CORRECTION AND RESPONSE UNIT

THREE ADDITIONAL INTEGRAL CORRECTION AND RESPONSE UNITS HAVE BEEN COMPLETED AND TESTED DURING THE SUBJECT WORK PERIOD. THREE OTHER UNITS ARE UNDER CONSTRUCTION.

5. SIMULATOR

THE SIMULATOR EQUIPMENT HAS BEEN DESIGNED AND CONSTRUCTED SO AS TO PROVIDE A MEANS OF TESTING THE STABILIZATION CONTROL SYSTEM THROUGH THE SIMULATION OF MISSILE FLIGHT CONDITIONS. CONSTRUCTION OF THE EQUIPMENT AND ITS INSTALLATION WAS COMPLETED DURING THE PRECEDING WORK PERIOD AND UTILIZED DURING PRESENT PERIOD FOR TESTS OF THE COMPLETE STABILIZATION SYSTEM. APPROXIMATELY TWENTY HOURS OF OPERATIONAL TESTS HAVE THUS FAR BEEN GIVEN TO THE COMPLETE STABILIZATION SYSTEM IN TESTS ON THE SIMULATOR, AND NECESSARY ADJUSTMENTS HAVE BEEN MADE IN SYSTEM CONSTANTS SO AS TO PROVIDE THE MOST SATISFACTORY OPERATION. CURVES FROM BRUSH RECORDER DATA ARE SHOWN IN FIGURE 18 AND INDICATE TYPICAL RESPONSE CHARACTERISTICS OF THE SIMULATOR TO SUDDEN DISTURBANCES IN ROLL AND PITCH. THE CONTROL SYSTEM NOW STABILIZES THE SIMULATOR TO A PLUS OR MINUS 0.25 DEGREES IN ROLL AND A PLUS OR MINUS 0.50 DEGREES IN PITCH AND YAW. THESE ERRORS ARE IN THE FORM OF LOW-FREQUENCY (APPROXIMATELY 1 CYCLE PER SECOND) EXCURSIONS ABOUT ZERO AND ARE NOT A STEADY ERROR CONDITION.

6. COMMAND CONTROL SYSTEM

WORK HAS BEEN STARTED ON THE COMMAND CONTROL AMPLIFIER AND MOTOR CONTROL UNIT FOR USE IN THE YAW SYSTEM OF TEST MISSILE NO. 2. THE MOTOR AND AUTOSYN INPUT UNIT HAS BEEN INCORPORATED IN THE SERVO RESPONSE HOUSING IN LIEU OF THE INTEGRAL CONTROL AND RESPONSE ELEMENTS WHICH WERE EMPLOYED FOR TEST MISSILE NO. 1 EQUIPMENT. TESTS ARE BEING CONDUCTED TO DETERMINE THE OVER-ALL ACCURACY OF THE SYSTEM.

C. TEST EQUIPMENT

THIS PROGRAM WAS INAUGURATED SO AS TO PROVIDE SUITABLE TEST EQUIPMENT TO FACILITATE TROUBLE SHOOTING AND FIELD TESTING OF STABILIZATION SYSTEM COMPONENTS. OF THESE, ONE UNIT, DESIGNATED AS THE STABILIZATION SYSTEM TEST PANEL, HAS BEEN COMPLETED AND TESTED DURING THE SUBJECT WORK PERIOD AND IS READY FOR USE BOTH IN STATIC FIRING TESTS AND IN PRE-FLIGHT TESTS. THE COMPLETED PANEL ASSEMBLY, FIGURE 19, HAS PROVISIONS FOR CONNECTING RECORDERS TO THE OUTPUT SIGNALS OF

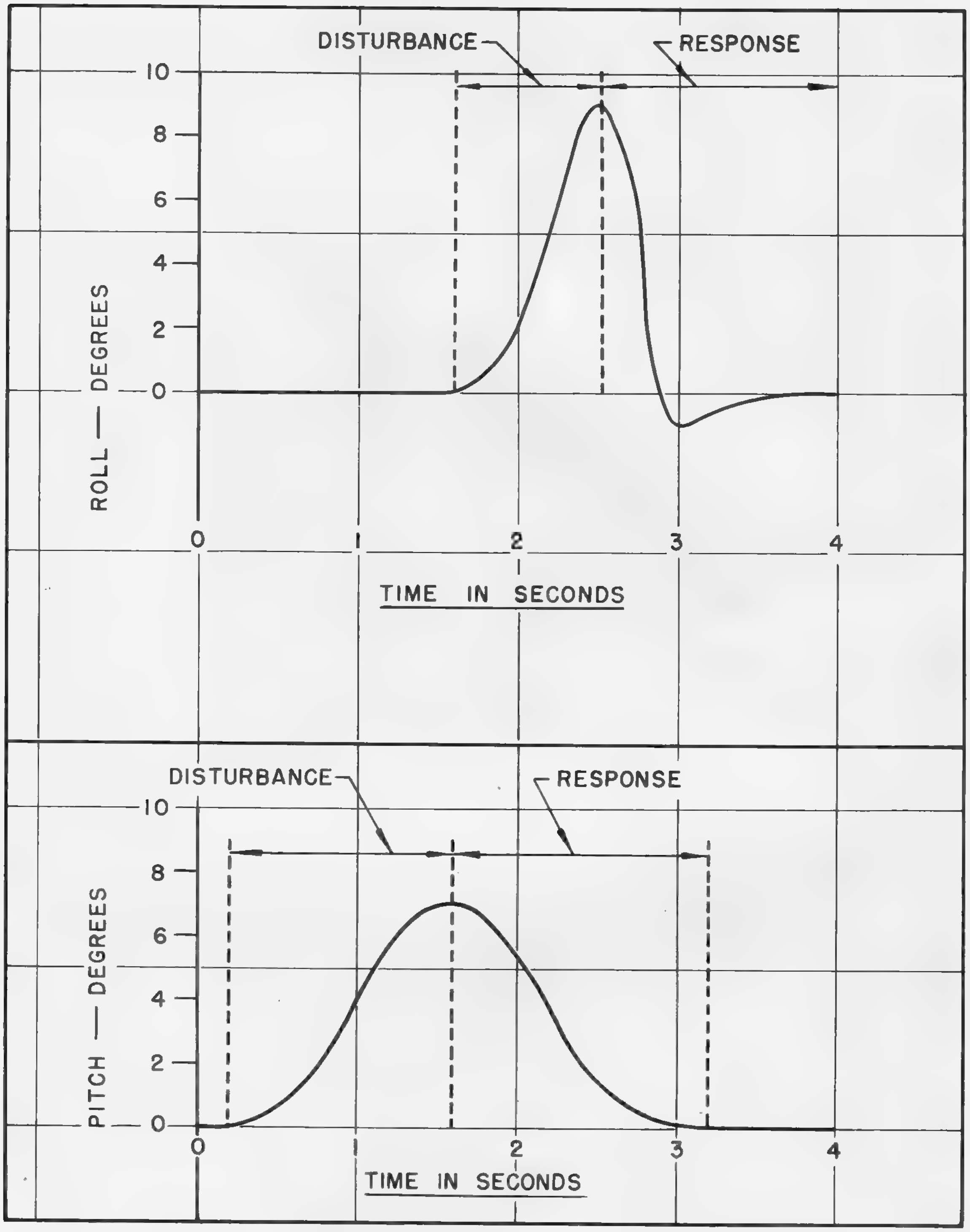

FIG. 18 -- TYPICAL RESPONSE CHARACTERISTICS OF THE SIMULATOR

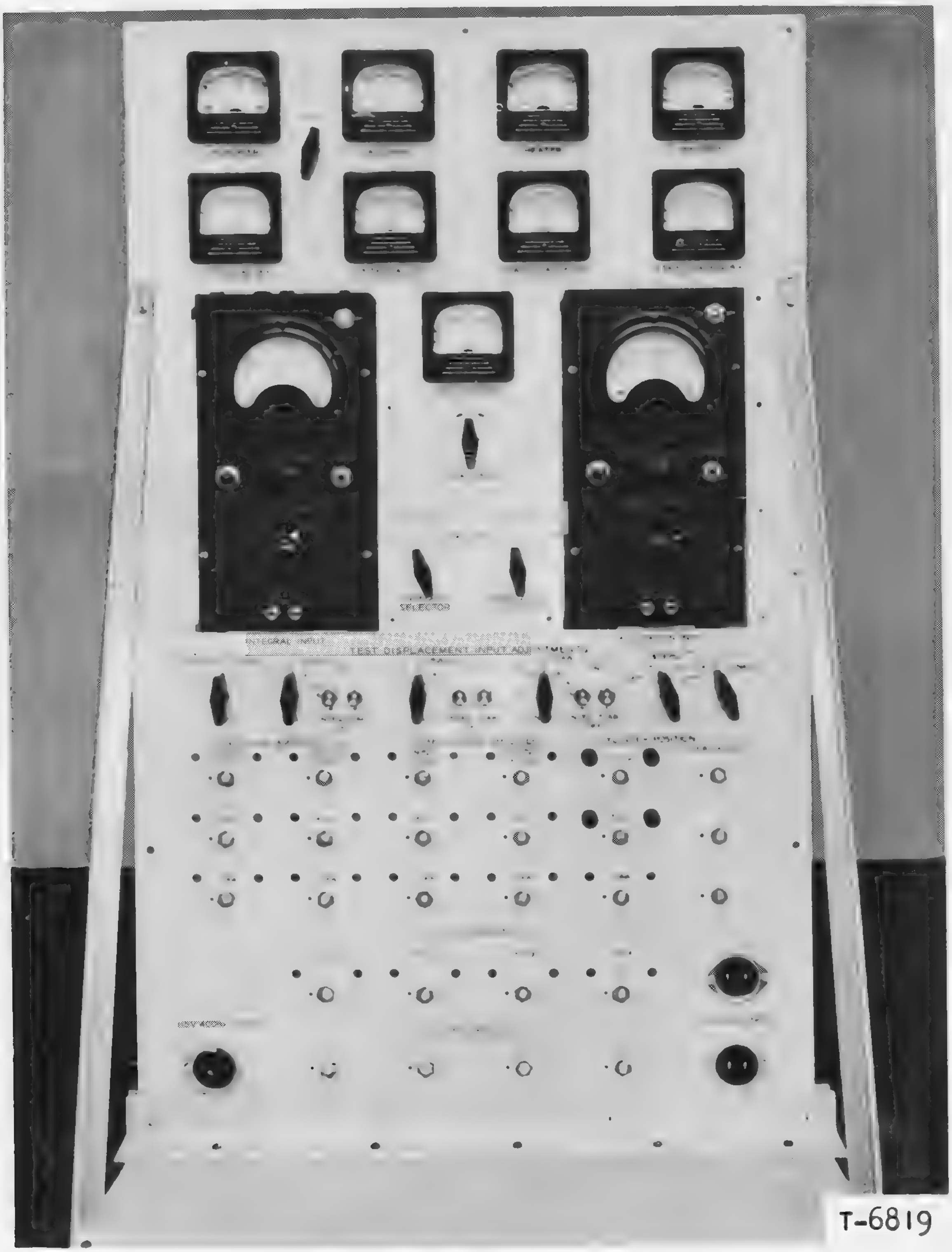

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FIG. 19 -- MX-774 STABILIZATION SYSTEM TEST PANEL

THE STABILIZATION SYSTEM. SINE WAVE GENERATORS IN THE ASSEMBLY PROVIDE A MEANS OF INTRODUCING A SINE WAVE ERROR SIGNAL WHILE THE STABILIZATION SYSTEM IS BEING OPERATED IN THE STATIC TEST STAND. TEST RUNS MADE WITH THE TEST PANEL CONNECTED INTO THE SIMULATOR WILL BE RECORDED FOR COMPARISON WITH STATIC TEST RUNS ON THE MISSILE.

CURTAILMENT OF THE TEST MISSILE PROGRAM RESULTED IN ABANDONMENT OF FURTHER EFFORTS AT CONSTRUCTING AN ADDITIONAL SET OF AMPLIFIER FIELD TEST PANELS AS MENTIONED IN REFERENCE 12. IN LIEU OF THIS EQUIPMENT, THE AMPLIFIER TEST PANEL, DESIGNED FOR TESTING INTEGRAL CORRECTION OR GUIDANCE AMPLIFIERS, HAS BEEN ADAPTED FOR FIELD USE.

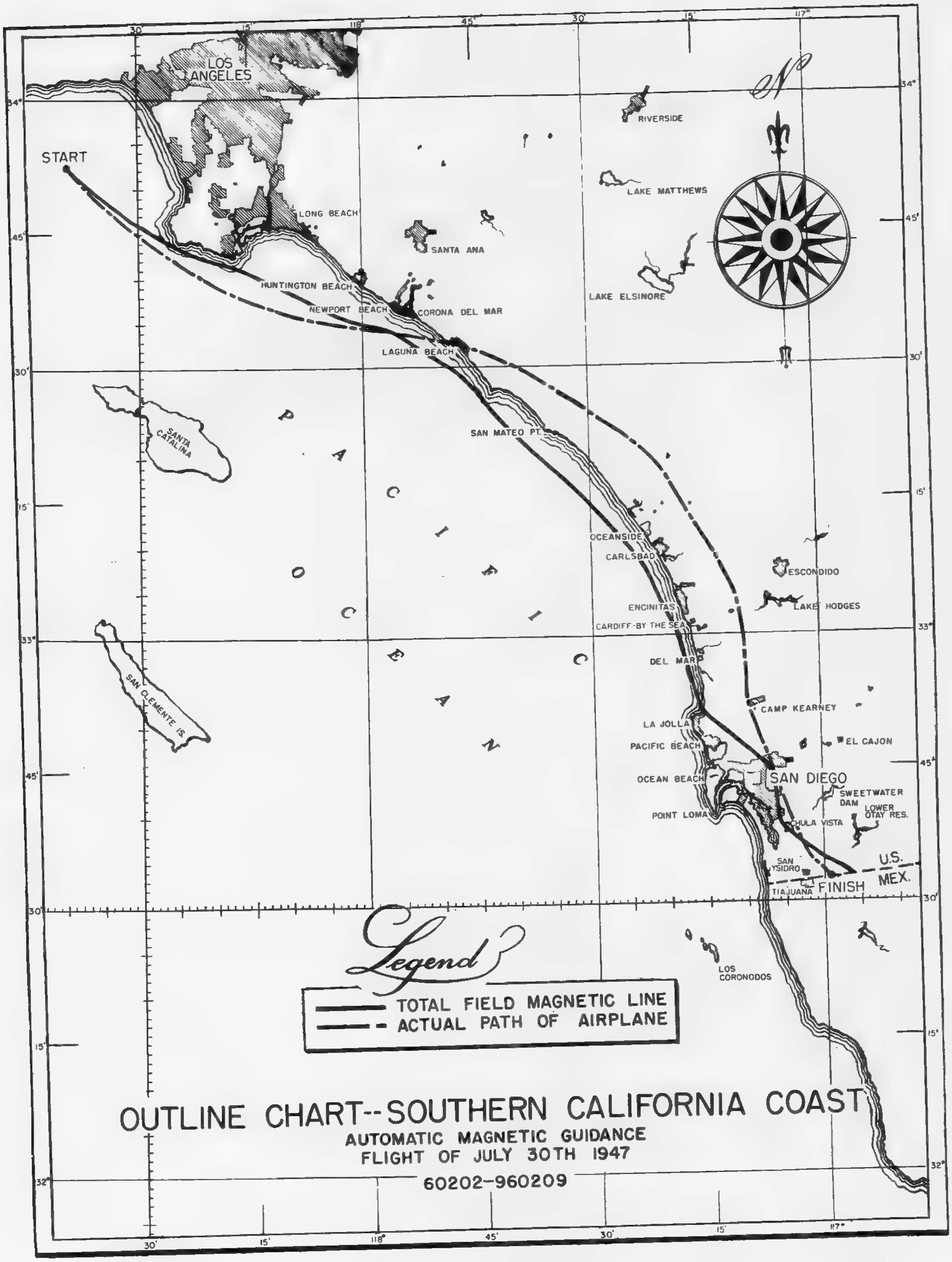

FIG. 20 -- FLIGHT PATH OF AIRPLANE ON MAGNETIC GUIDANCE

SECTION VII
GUIDANCE AND INTELLIGENCE

A. MAGNETIC NAVIGATION STUDIES AND EXPERIMENTS

Considerable progress was made in magnetic navigation during July and August, the most notable achievement being a complete flight by an airplane controlled in yaw solely by means of automatic magnetic guidance equipment following a line of constant total terrestrial magnetic field intensity.

The guided flight was made on 29 July 1947 with a C-46F type aircraft and originated at a point approximately ten miles off-shore at Santa Monica, California. The flight terminated at a point a few miles east of San Diego, California. As shown in Figure 20, the course distance was approximately 160 miles. Greatest deviation from the desired course was caused by an anomaly occurring near mid-point of the flight. In spite of this the automatic magnetic guidance equipment returned the aircraft to the magnetic line, effectively by-passing the disturbance. The flight was conducted at an elevation of 12,000 feet to reduce effects produced by local anomalies that might be encountered. The magnetic guidance equipment fed a signal to a rate-and-error computer which in turn energized a ratchet-type solenoid attached to the rudder control of a type A-3A auto-pilot as shown in Figure 21. With this method, whenever the aircraft deviated from the selected magnetic line, the auto-pilot received a left or right rudder correction, whichever was required, thus returning the aircraft to the magnetic line. It is expected that other flights will be made over longer courses including those wherein a specific target is selected as the terminal objective. With respect to the latter, it is of interest to note that data obtained during this first automatic magnetically guided flight indicated a rise in the total magnetic field intensity equal to approximately 70 gammas upon reaching the outskirts of the city of San Diego. Since this phenomenom is typical of cities in the northern hemisphere, consideration is being given to its utilization in target selection.

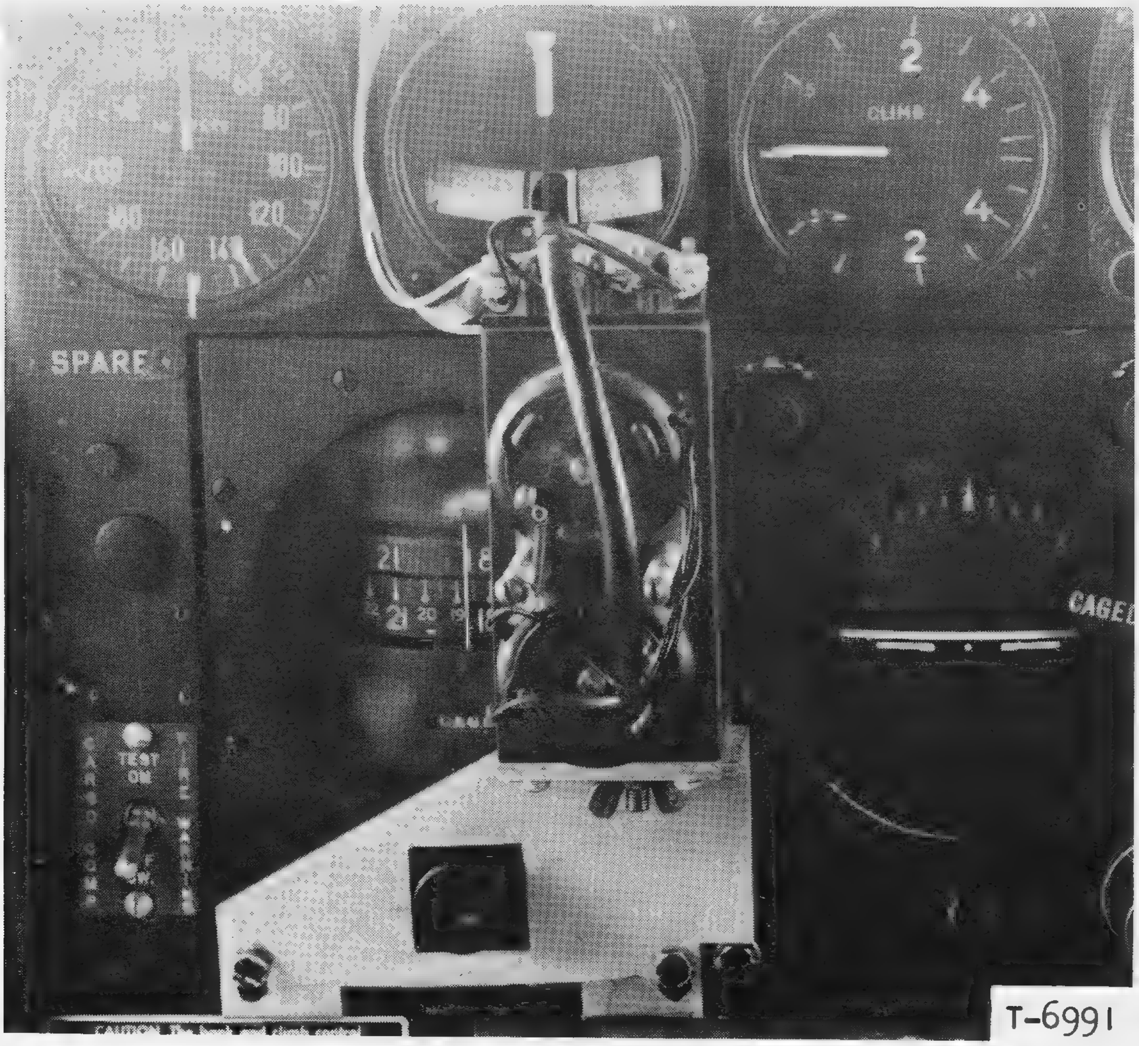

FIG. 21 -- RATCHET SOLENOID ATTACHMENT TO AUTOPILOT FOR RUDDER CONTROL

RECEIVED DURING THE CURRENT REPORT PERIOD, THE AN/ASQ-3 MAGNETIC DETECTION EQUIPMENT WAS SET UP IN THE LABORATORY AND BENCH-TESTED. WHILE THESE TESTS WERE INCONCLUSIVE, IT IS EXPECTED THAT FURTHER TESTS TO BE CONDUCTED DURING THE ENSUING WORK PERIOD WILL DETERMINE USEFULNESS OF THE EQUIPMENT FOR THE INTENDED APPLICATION. IT WAS LEARNED THAT SIMILAR EQUIPMENT EMPLOYED BY CERTAIN GEOPHYSICAL FIRMS FOR THE PURPOSE OF OBTAINING ABSOLUTE MEASUREMENTS INCORPORATED A LATE MODIFICATION ON WHICH ADDITIONAL INFORMATION HAS NOW BEEN REQUESTED.

A NUMBER OF FIELD TESTS ALSO WERE MADE DURING THE SUBJECT WORK PERIOD. THESE WERE CONDUCTED AT A MAGNETICALLY QUIET LOCATION NEAR SAN YSIDRO, CALIFORNIA, THEIR PURPOSE BEING THE DETERMINATION OF MAGNITUDE AND DIRECTION OF THE OVER-ALL MAGNETIC GUIDANCE EQUIPMENT DRIFT. SUFFICIENTLY REPETITIVE RESULTS WERE OBTAINED TO PERMIT ESTABLISHMENT OF A FIXED VALUE FOR SYSTEM DRIFT.

A SEARCH FOR A HIGHLY STABILIZED D-C SOURCE ALSO WAS SUCCESSFULLY CONCLUDED DURING THE SUBJECT WORK PERIOD. IT WAS FOUND THROUGH LABORATORY EXPERIMENTS THAT THE CLOSE TOLERANCE REQUIREMENTS FOR AIRBORNE APPLICATIONS OF THE AUTOMATIC MAGNETIC GUIDANCE EQUIPMENT WERE BEST SATISFIED BY THE USE OF A DRY BATTERY. FOR THE PROPOSED APPLICATION, THE RATE OF DECREASE IN VOLTAGE AS COMPARED WITH TIME WAS FIRST DETERMINED WITH RESPECT TO THE AVERAGE CURRENT LOAD. A MOTOR-DRIVEN HELIPOT THEN WAS USED TO REMOVE CIRCUIT RESISTANCE IN ACCORDANCE WITH THE VOLTAGE DECAY OF THE BATTERY, PROVISION ALSO BEING MADE IN THE HELIPOT'S OPERATION TO ALLOW FOR THERMAL DRIFT OF THE ELECTRONIC AMPLIFIERS.

B. PRECISION MISSILE TRACKING SYSTEM

ORIGINALLY INAUGURATED AS A RESEARCH AND ANALYTICAL PROGRAM, THE PRECISION MISSILE TRACKING SYSTEM HAS PROGRESSED TO THE EXPERIMENTAL STAGE WITH VARIOUS COMPONENT UNITS REQUIRED FOR THE SYSTEM NOW BEING GROUPED UNDER THIS SINGLE HEADING AS IDENTIFIED BY THE RELATED SUB-HEADING. SOME OF THESE UNITS WERE LAUNCHED AS SEPARATE RESEARCH AND/OR EXPERIMENTAL PROJECTS UNDER THE OVER-ALL CONTRACTUAL AUTHORITY BUT HAVE NOW BEEN INCLUDED IN THIS SPECIFIC PROGRAM DUE TO THEIR MEETING THE REQUIREMENTS FOR THIS PROPOSED SYSTEM. ALL WORK OF ANALYTICAL OR RESEARCH NATURE PREVIOUSLY UNDERTAKEN ON THIS PROGRAM HAS BEEN SUSPENDED PENDING COMPLETION OF TESTS PLANNED FOR THE POSITION TRACKER SYSTEM AND OTHER COMPONENT SECTIONS WHICH FORM A PART OF THE OVER-ALL PRECISION MISSILE TRACKING SYSTEM.

1. VHF TEST MODEL PHASE COMPARISON SYSTEM

THE WORK PROGRAM PREVIOUSLY UNDERTAKEN FOR THE PURPOSE OF MAKING A VHF TEST OF THE HYPERGRID SYSTEM (SUBSONIC GUIDANCE) RESULTED IN ACCUMULATION OF VARIOUS COMPONENTS AND EQUIPMENT UNITS. AS A RESULT, CERTAIN UNITS OF TEST EQUIPMENT HAVE BEEN MADE AVAILABLE TO THE VHF POSITION TRACKER PROGRAM, ANOTHER METHOD EMPLOYING PHASE COMPARISON TO DETERMINE POSITION. WORK MAY BE RESUMED ON THE SUBJECT PROGRAM AT A LATER DATE.

2. VHF Position Tracker

The position tracker system furnishes the computer continuous information as to the missile's position in space. This information is obtained by receiving, at three or more points on the ground, signals transmitted from the missile and measuring the phase difference of the received signals. Azimuth positioning requires two or more points of reception preferably located on a line perpendicular to the flight path plane and at known geographic positions, whereas, elevation positioning requires two or more points of reception located in or parallel to the plane of the missile's flight and at right angles to those points of the azimuth system. However, one reception point may be common to both positioning systems. The information so obtained is then utilized in a computer, together with range and velocity information, to determine deviation of the missile from a preassigned course. Figure 22 shows a block diagram of the VHF system under discussion. Both elevation and azimuth tracking functions are diagrammed.

It is planned that Test Missile No. 1 will be fired without utilizing position tracking control; Missile No. 2 will be tracked in azimuth only. A block diagram of the position tracker system as modified to track azimuth only is shown in Figure 23. Missile No. 3 is expected to be tracked in both azimuth and elevation. To track the missiles, the following equipment has been constructed:

A. Pressurized VHF transmitters, except for their cases, have been completed for Test Missiles No. 2 and 3. These operate at a frequency of 150 mc, employ integral dynamotor power supplies, and have been given extensive vibration tests and heat runs with satisfactory results.

B. Three receivers have been constructed and tested, thus providing three ground station reception channels. A fourth receiver is under construction and should be completed and tested during the next work period. The differential phase shift between any two channels may be held to less than 3 degrees for a 60 db change in signal amplitude and less than 1 degree for a 400 kc change in frequency. Control accuracies of this order indicate that the total phase error in the equipment should be less than 2 degrees over the expected operating range, approximately 200 miles as presently planned.

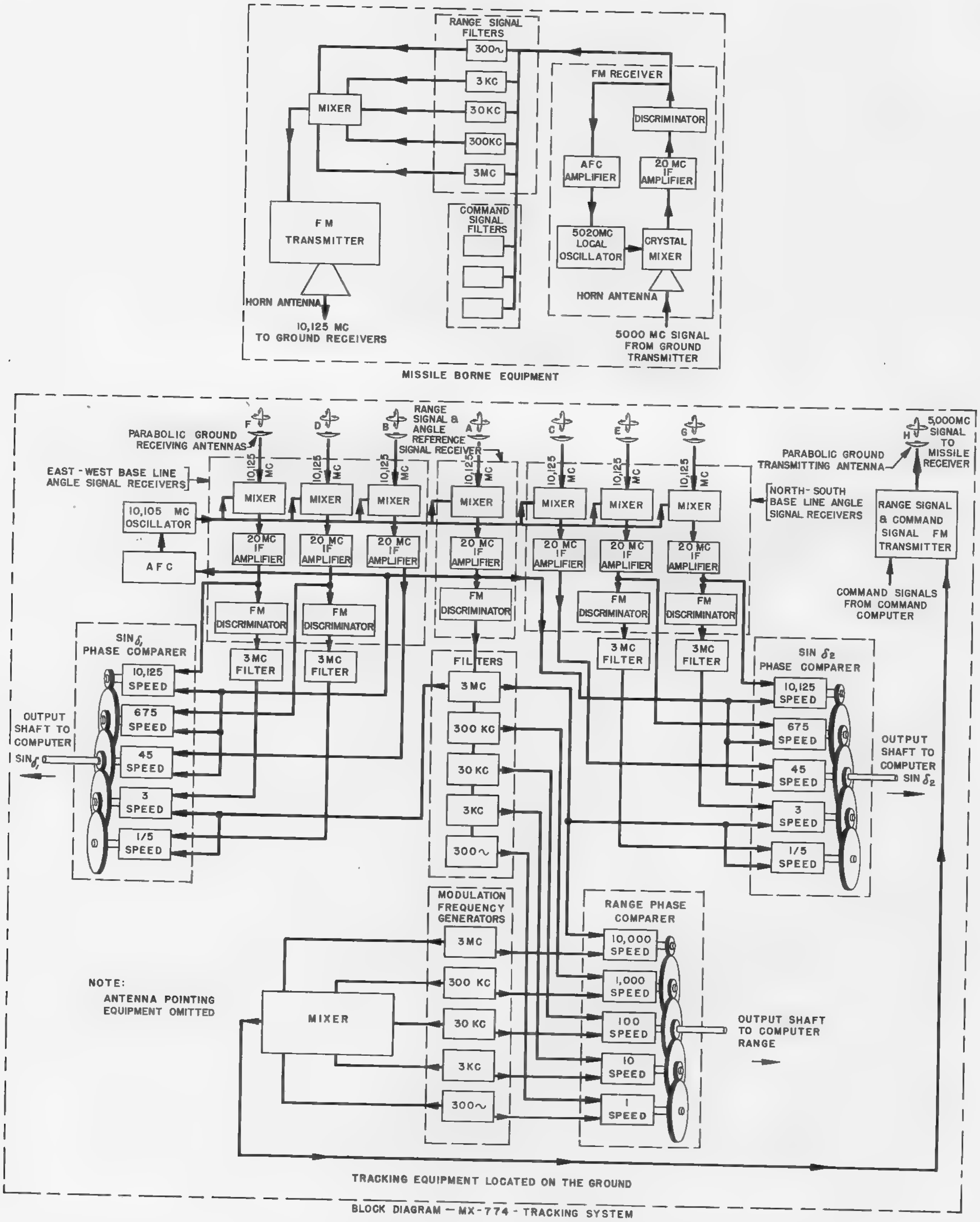

FIG. 22 -- VHF POSITION TRACKER SYSTEM BLOCK DIAGRAM

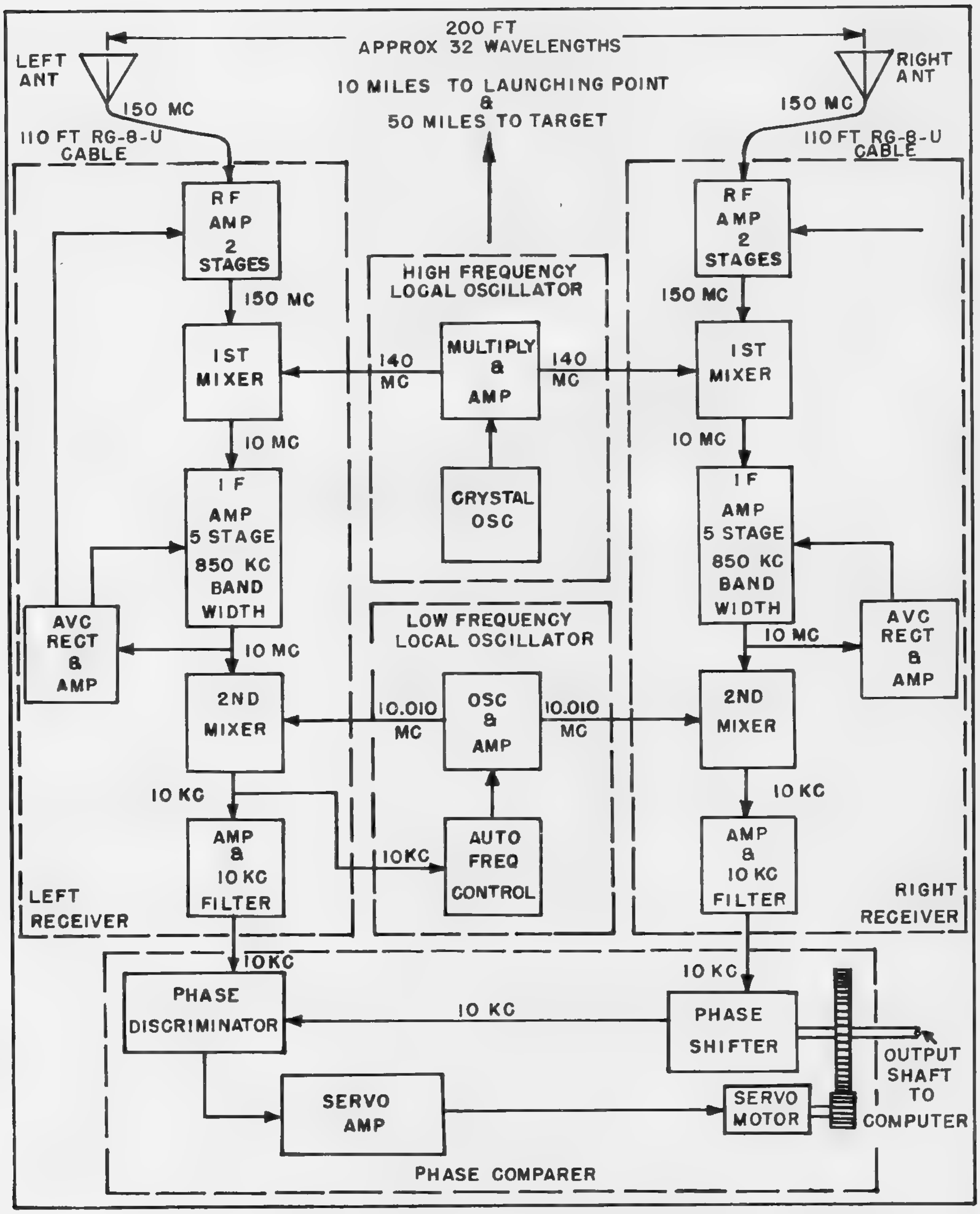

FIG. 23 -- AZIMUTH TRACKING SYSTEM BLOCK DIAGRAM

C. THREE PARASITIC-TYPE YAGI ARRAYS, FORMERLY USED WITH THE HYPERGRID SYSTEM, HAVE BEEN ALTERED TO PERMIT THEIR USE AS ANTENNAS WITH THE POSITION TRACKER SYSTEM RECEIVERS. THESE ARRAYS PROVIDE A BEAM-WIDTH OF APPROXIMATELY 70 DEGREES WITH BACK LOBES OF LESS THAN 2 PERCENT AND A POWER GAIN OF APPROXIMATELY 10 DB.

D. THE PHASE COMPARER USED WITH THE AZIMUTH TRACKER EQUIPMENT HAS BEEN COMPLETED DURING THE SUBJECT WORK PERIOD AND HAS BEEN GIVEN OPERATIONAL TESTS. AZIMUTH TRACKER COMPONENTS ARE SHOWN IN FIGURE 24. THE PHASE COMPARER TO BE USED WITH ELEVATION TRACKER EQUIPMENT IS UNDER CONSTRUCTION AND IS TO BE COMPLETED DURING THE ENSUING WORK PERIOD. DESIGN OF THE INDICATORS, HOWEVER, HAS BEEN POSPONED PENDING A BETTER REALIZATION OF COMPUTER REQUIREMENTS.

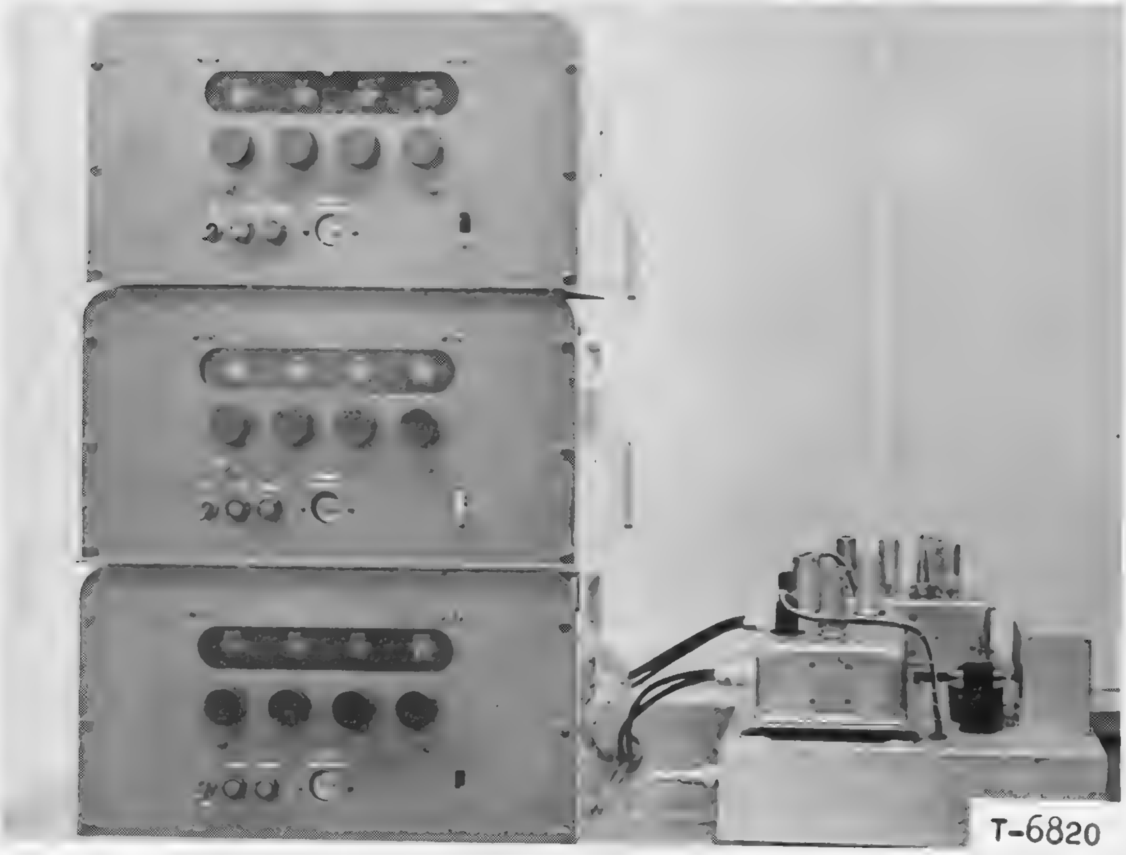

FIG. 24 -- AZIMUTH TRACKER COMPONENTS OF POSITION TRACKER SYSTEM

The phase comparer equipment is comprised of various components which may be designated as follows: (a) phase shifter, (b) phase discriminator, (c) servo amplifier, and (d) servo motor. Arrangement of these units is shown in the lower portion of the azimuth tracker system block diagram, Figure 23. The phase comparer is required to convert output data from the position tracker equipment to a form suitable for use in the computer. Data from the tracking system for measurement of one specific angle are determined by the phase difference existing between two 10 kc signals. This difference in phase begins at a given reference level and may rotate through several cycles as the test vehicle is tracked. It is planned to convert this data into mechanical shaft rotation for use in the computer as required for azimuthal guidance of MX-774 Test Vehicle No. 2.

The phase difference between two 10-kc channels is measured by automatically shifting the phase of one channel so the resultant phase difference is zero. The position of the phase shifter then becomes a function of the original phase difference.

Automatic phase shifting is accomplished as follows. The output from the phase shifter and another 10-kc signal provided by the tracking system are compared in the phase discriminator, the output of which is amplified and coupled into a servo amplifier. The output of the servo amplifier then operates a servo motor which drives the output shaft and the phase shifter. The signal output from the phase discriminator functions as an error signal and causes the output shaft and phase-shifting transformer to rotate until the error signal approaches zero. In other words, rotation of the output shaft is made proportional to the phase difference of the two input signals. This equipment has been set up in functional mock-up form the arrangement of which is shown in Figure 25 with mechanical details illustrated in Figure 26.

3. Doppler Speedometer Experiments and Design

Work on this program included completion of overall operational tests of the Doppler speedometer system. In addition, a number of ground checks were made of the system, and three flight tests were conducted between a high elevation ground station and the repeater station installed within a C-46 type aircraft. Operation of the system proved satisfactory, a continuous indication of the aircraft's speed being provided the ground station while the aircraft was flying at an altitude of 7000 feet and at a range of 100 miles.

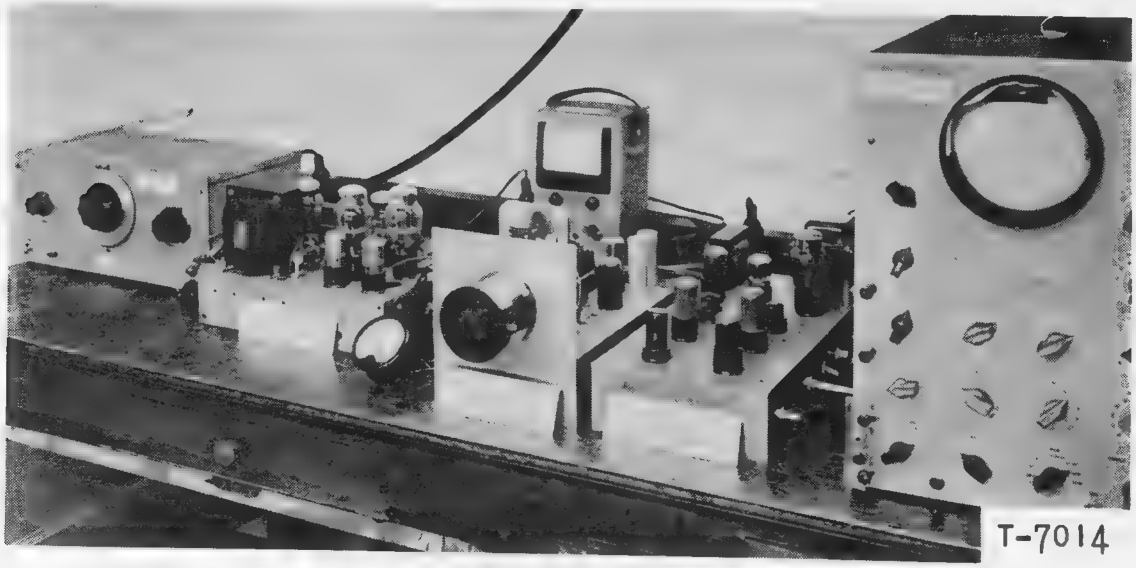

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FIG. 25 -- COMPONENTS OF AZIMUTH PHASE COMPARER

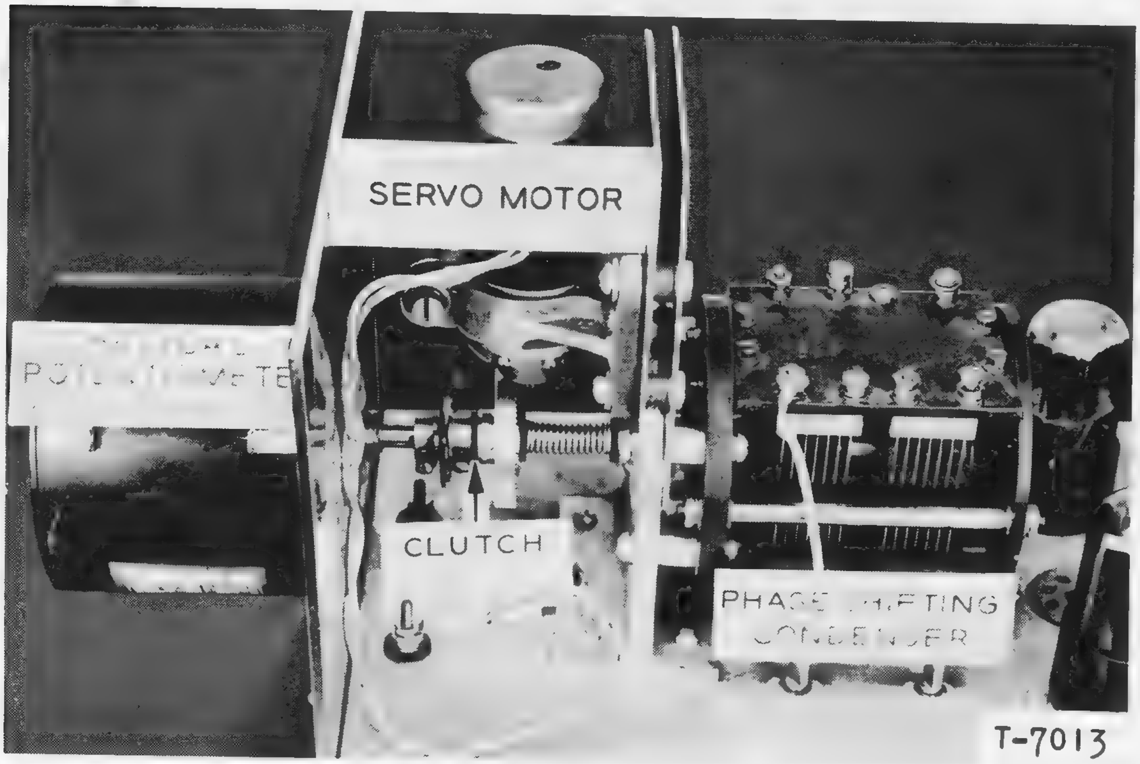

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FIG. 26 -- DETAIL OF AZIMUTH PHASE COMPARER

PRIOR TO THESE TESTS, A SERIES OF BENCH TESTS MADE OF THE REPEATER STATION POINTED UP THE NECESSITY FOR ELIMINATING INTERFERENCE EMANATING FROM ADJACENT TELEMETERING EQUIPMENT. THIS WAS ACCOMPLISHED BY MODIFYING THE VARIOUS COMPONENTS OF THE REPEATER STATION: I.E., CHANGING THE LOCAL OSCILLATOR ASSEMBLY TO A QUADRUPLER TYPE, PROVIDING THE LIMITER CIRCUIT WITH A MORE POSITIVE ACTION TO REDUCE POSSIBILITY OF ACTUATION OF THE FUEL SHUT-OFF RELAY BY AN INTERFERING SIGNAL, AND CHANGING THE SHUT-OFF RELAY TO A STEPPING-TYPE TO PROVIDE A SEQUENCE OF FOUR CONTROL OPERATIONS.

IN ADDITION, CONSTRUCTION WAS STARTED OF ANOTHER REPEATER STATION UTILIZING A DESIGN WHICH INCORPORATES ALL IMPROVEMENTS FOUND NECESSARY IN THE PRECEDING MODEL. ALSO UNDER CONSTRUCTION IS A TRF-TYPE OF FREQUENCY-DOUBLING REPEATER STATION WHICH IS TO REPLACE THE SUPERHETERODYNE-TYPE UNIT WHEN USING THE RANGE MEASURING EQUIPMENT IN CONJUNCTION WITH THE DOPPLER EQUIPMENT. THIS TYPE OF REPEATER STATION IS MORE DESIRABLE FOR RANGE MEASUREMENT BECAUSE IT DISPLAYS A HIGHER PHASE FIDELITY.

AFTER 100 HOURS OF SATISFACTORY OPERATION, THE GROUND STATION EQUIPMENT WAS CHECKED AND SERVICED AND FOUND TO BE IN EXCELLENT CONDITION. FOR TEST PURPOSES, A 72-MEGACYCLE TEST OSCILLATOR HAS BEEN MADE TO PROVIDE SUFFICIENT OUTPUT TO OPERATE THE REPEATER STATIONS AT DISTANCES UP TO 100 FEET. FIELD TESTS WERE FACILITATED BY CONSTRUCTION OF TWO PORTABLE FIELD-STRENGTH METERS AND TWO PORTABLE BATTERY-POWERED CRYSTAL-CONTROLLED SIGNAL GENERATORS. TO INSURE COMPLETE ACCURACY OF TESTS MADE WITH THIS EQUIPMENT, COMPLETE INSTRUCTIONS COVERING THE TEST PROCEDURE HAVE BEEN WRITTEN.

4. DOPPLER RANGE MEASUREMENT SYSTEM

WORK ON THIS PROGRAM WAS INITIATED DURING THE MONTH OF JULY WITH THE OBJECTIVE OF DEVELOPING A PRECISION SYSTEM FOR DETERMINING RANGE OF A MISSILE WITH RESPECT TO A GROUND STATION. AS THE RESULT OF INITIAL EFFORTS EXPENDED ON THIS PROGRAM, A RANGE MEASURING SYSTEM HAS BEEN DESIGNED WHICH UTILIZES THE DOPPLER SPEEDOMETER GROUND STATION TRANSMITTER AND ITS ASSOCIATED AIRBORNE REPEATER STATION FOR THE TRANSMISSION OF INTELLIGENCE SIGNALS. THE LATTER SIGNALS ARE USED TO FREQUENCY MODULATE THE DOPPLER GROUND STATION. THE RESULTING MODULATED SIGNALS ARE TRANSMITTED TO THE AIRBORNE REPEATER STATION WHEREIN THE CARRIER FREQUENCY IS RECEIVED, AMPLIFIED, DOUBLED, AND THEN RE-TRANSMITTED TO THE GROUND STATION. A

FREQUENCY MODULATION-TYPE RECEIVER IS EMPLOYED AT THE GROUND STATION TO RECEIVE AND DEMODULATE THE RETURNED SIGNAL RECEIVED FROM THE AIRBORNE REPEATER STATION. BY COMPARING ELECTRONICALLY THE PHASE OF THE RETURNED INTELLIGENCE SIGNALS WITH THAT OF THE ORIGINAL MODULATED SIGNALS, A PHASE DIFFERENTIAL WILL BE ESTABLISHED WHICH WILL BE EXACTLY PROPORTIONAL TO THE DISTANCE THAT THE SIGNALS HAVE TRAVERSED. THE OUTPUT OF THIS RANGE MEASURING SYSTEM IS REQUIRED TO BE SUITABLE FOR DIRECT APPLICATION TO A COMPUTER.

FUNDAMENTALLY, THE RANGE MEASURING EQUIPMENT CONSISTS OF FIVE BASIC UNITS, AS FOLLOWS:

(A) INTELLIGENCE SIGNAL GENERATOR AND FILTER UNIT
(B) FREQUENCY MODULATION RECEIVER
(C) PHASE COMPARISON UNIT
(D) SERVO AMPLIFIER AND CONTROL UNIT
(E) SERVO AND PHASE ROTATING TRANSFORMER UNIT

THE LAST THREE OF THESE UNITS HAVE BEEN CONSTRUCTED AND TESTED; CONSTRUCTION IS UNDERWAY ON THE OTHERS.

IN ADDITION TO THESE FIVE BASIC UNITS, AN OSCILLOSCOPE IS TO BE ADDED TO THE EQUIPMENT RACK SO AS TO PROVIDE TEST MONITORING OF SYSTEM OPERATION. A SIMULATOR ALSO WILL BE NECESSARY TO FACILITATE CALIBRATION OF THE SYSTEM. THESE UNITS ARE UNDER CONSTRUCTION IN THE LABORATORY.

5. COMMAND CONTROL SYSTEM

WORK ON THIS PROGRAM WAS INITIATED DURING AUGUST TO PROVIDE SUITABLE COMMAND CONTROL EQUIPMENT FOR GUIDANCE OF TEST MISSILES. THE PHASE-SHIFT TYPE OF COMMAND CONTROL SYSTEM WAS CHOSEN AS THE MEANS OF CONVEYING GUIDANCE INTELLIGENCE SINCE A THREE-CHANNEL GROUND STATION UTILIZING THIS METHOD OF CONTROL IS ALREADY COMPLETE AND AVAILABLE TO THE PROJECT. THE FIRST TEST MISSILE TO EMPLOY THIS FORM OF GUIDANCE WILL REQUIRE CONTROL ONLY IN AZIMUTH, AND CONSEQUENTLY, THE FIRST COMMAND CONTROL SYSTEM DESIGNED FOR INSTALLATION WITHIN THE MISSILE WILL BE OF THE SINGLE-CHANNEL TYPE (FIGURE 23). THE COMMAND CONTROL SYSTEM DESIGNED FOR INSTALLATION IN TEST MISSILE NO. 2 WILL BE OF THE TWO-CHANNEL TYPE AND WILL INCORPORATE ELEVATION CONTROL.

THE SINGLE-CHANNEL AIRBORNE SYSTEM HAS BEEN DESIGNED AND CONSTRUCTED IN MOCK-UP FORM SO AS TO PROVIDE THE NECESSARY TEST INFORMATION REQUIRED TO DESIGN THE FINAL MODEL. THE SECOND AIRBORNE SYSTEM WILL INCLUDE A RECEIVER, A TWO-CHANNEL FILTER, TWO PHASE-DISCRIMINATOR AND SERVO-AMPLIFIERS, AND TWO SERVO-CONTROLLED FOLLOW-UPS. ON COMPLETION OF TESTS CONDUCTED WITH THESE MOCK-UP SYSTEMS, DESIGN OF THE FINAL MODELS WILL BE COMPLETED.

SECTION VIII
TELEMETERING

A. TELEMETERING FOR THE TEST VEHICLE

THE RECORDING OSCILLOGRAPH RECENTLY RECEIVED FROM THE ARMY FOR USE ON MX-774 TELEMETERING GROUND STATION NUMBER I WAS FOUND TO HAVE NO PROVISION FOR INDICATING MOVEMENT OF THE PHOTO PAPER. SINCE A CERTAIN KNACK OF LOADING THE PAPER IS REQUIRED TO PREVENT JAMMING, IT WAS DEEMED ADVISABLE TO INSTALL ON THE FRONT PANEL A SMALL LAMP WHICH BLINKS AS LONG AS THE PAPER IS MOVING. DURING TESTS OF THE OSCILLOGRAPH, A 60-CYCLE RIPPLE WAS PREVALENT ON ALL GALVANOMETER TRACES. AN OUTPUT FILTER PLACED IN THE DISCRIMINATOR CIRCUITS REDUCED THIS RIPPLE TO A POINT WHERE IT IS NEGLIGIBLE, WITHOUT IMPAIRING RESPONSE IN THE REGION WHERE TELEMETERING SIGNALS ARE ANTICIPATED.

EXCESSIVE HARMONIC DISTORTION WAS ENCOUNTERED IN THE R-F UNITS FOR TEST MISSILE NO. I. CAUSE OF THE TROUBLE WAS TRACED TO 6C4 TUBES IN THE DOUBLER STAGES; THESE WERE REPLACED WITH 6AQ5'S. DOUBLER CIRCUIT CONSTANTS WERE RE-ADJUSTED FOR THE NEW TUBES AND THE HARMONIC DISTORTION THUS ELIMINATED.

A FLIGHT TEST OF THE AIRBORNE TELEMETERING EQUIPMENT FOR TEST MISSILE NO. I AND THE GROUND STATION WAS CONDUCTED WITH SATISFACTORY RESULTS. THE AIRBORNE EQUIPMENT WAS FLOWN IN AN ARMY C-46 TRANSPORT WITH THE GROUND STATION SET UP ON MOUNT SOLEDAD (820 FEET ABOVE SEA LEVEL). A SWITCH WAS USED TO SIMULATE THE PICKUPS. THE UNIT'S RANGE WAS MUCH GREATER THAN ANTICIPATED. TWO COURSES WERE FLOWN DURING THE TEST, ONE BEING INLAND OVER MOUNTAINOUS TERRAIN AND THE OTHER OVER WATER. FADING WAS ENCOUNTERED AT DISTANCES OVER 150 MILES ON THE FIRST COURSE, BUT THE SIGNAL WAS HEARD AND RECORDED SUCCESSFULLY AT DISTANCES UP TO 250 MILES. THE OVER-WATER COURSE WAS FLOWN FOR APPROXIMATELY 125 MILES WITH EXCELLENT RESULTS.

GROUND STATION NUMBER 2 WAS FOUND TO HAVE CONSIDERABLE INHERENT NOISE WHICH WAS TRACED TO LEAKAGE IN THE PAPER TAPE ON THE DISCRIMINATOR COILS. THE COILS WERE THEN REWOUND AND IMPREGNATED WITH THE RESULT THAT INHERENT NOISE IS NEGLIGABLE. THE TWO R-F UNITS BUILT FOR TELEMETERING USE IN THE TEST MISSILE NO. 2 HAVE BEEN COMPLETED AND ARE UNDERGOING OPERATIONAL TESTS AT PRESENT. PLAN PICTURES OF ONE OF THESE UNITS ARE SHOWN IN FIGURES 27 AND 28.

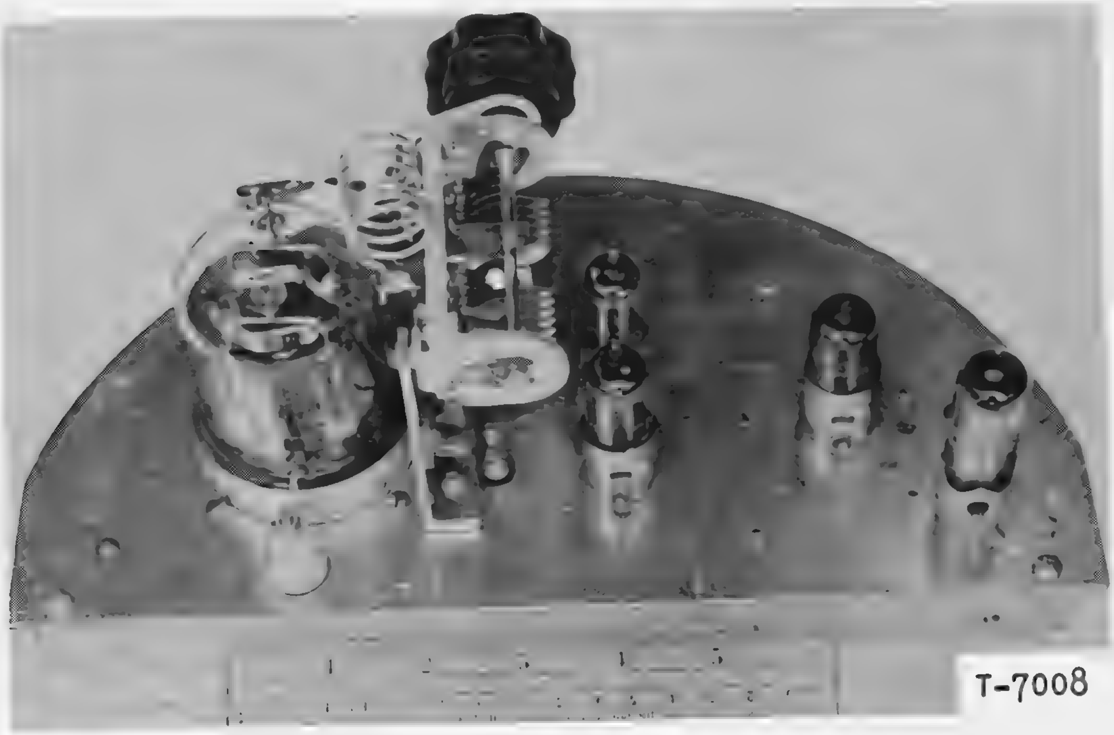

FIG. 27 -- TELEMETERING R-F UNIT FOR MISSILE NO. 2

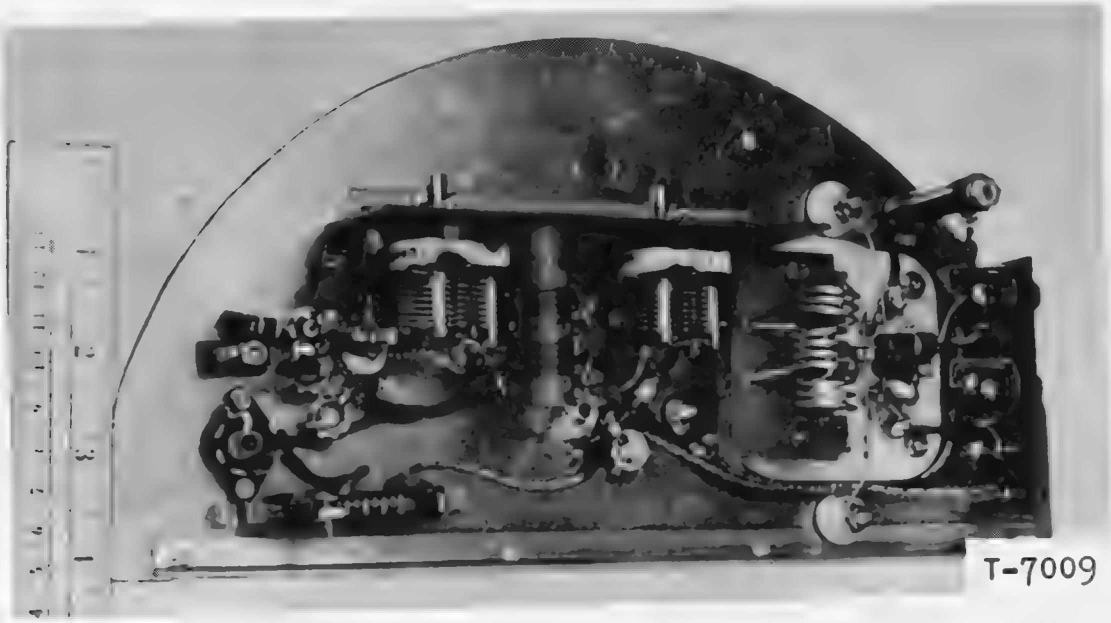

FIG. 28 -- UNDERSIDE VIEW OF TELEMETERING R-F UNIT

DATA TO BE RECORDED VIA AIRBORNE AND GROUND STATION TELEMETERING EQUIPMENT ARE LISTED IN REFERENCE 11.

A NEW DESIGN IS BEING WORKED OUT FOR TELEMETERING OF FUTURE MX-774 MISSILES. THE TELEMETERING EQUIPMENT WILL BE COMPACTLY ARRANGED SO THAT IT MAY BE HOUSED IN A CYLINDRICAL, PRESSURIZED CAN HAVING A SIX-INCH RADIUS AND A TWENTY-INCH LENGTH. THIS NEW ARRANGEMENT PROVIDES GREATER EFFICIENCY AND BETTER MECHANICAL ACCESSIBILITY. THE FIRST R-F SECTION CONSTRUCTED UNDER THIS NEW DESIGN FUNCTIONS EXTREMELY WELL. DUE TO THE HIGHER EFFICIENCIES OBTAINABLE WITH THE NEW DESIGN, THE 6AQ5 DOUBLER STAGE AS USED ON TEST MISSILE NO. 1 EQUIPMENT PROVIDES AN EXCESSIVE AMOUNT OF DRIVE FOR THE 829-B FINAL STAGE. TYPE 6AK6 TUBES WILL BE EMPLOYED AS DOUBLERS TO ALLEVIATE THIS CONDITION.

B. MOVABLE GRID TUBE FOR VACUUM TUBE GYRO

WORK ON THIS PROGRAM WAS SUSPENDED IN MID-JULY DUE TO TRANSFER OF PERSONNEL TO OTHER LABORATORY WORK OF HIGHER PRIORITY. HOWEVER, SEVERAL TESTS WERE COMPLETED WHICH INDICATED A NON-UNIFORMITY OF OUTPUT IN VARIOUS DEGREES OF GRID DEFLECTION. THIS BECAME NOTICEABLE BECAUSE OF IMPROVEMENTS IN OTHER TECHNIQUES TO THE POINT WHERE THE TUBES HAVE BECOME MORE STABLE IN OPERATION. IN WAS FOUND THAT NON-UNIFORMITY OF OUTPUT HAS BEEN CAUSED BY IRREGULARITY OF THE GRID STRUCTURE. AN IMPROVED GRID WELDING AND STRETCHING MANDREL HAS BEEN DESIGNED AND AN ORDER PLACED FOR ITS CONSTRUCTION. IT IS BELIEVED THAT THIS NEWLY DESIGNED MANDREL WILL FACILITATE CONSTRUCTION OF A MORE UNIFORM GRID.

TO DETERMINE UNIFORMITY OF OUTPUT IN RELATION TO ANGULAR POSITION, CURVES WERE PLOTTED OF THE TESTS MADE WITH FOUR TUBES. THE CURVES WERE FURTHER CHECKED BY PLOTTING A SINE WAVE OVER THE RECORDED TUBE OUTPUT. A NUMBER OF IRREGULARITIES WERE NOTED. BY COMPARING CATHODE EMISSION AND GRID SHAPES AS TO THEIR EFFECTS ON IRREGULARITIES, THE GRIDS WERE DETERMINED TO BE THE CAUSE.

IN ADDITION, TESTS WERE MADE OF CATHODE AGING. THIS WAS A CONTINUATION OF THE EFFORTS REPORTED IN THE MAY-JUNE BI-MONTHLY REPORT TO ESTABLISH FINITE LIMITS OF CATHODE CURRENT AND OTHER ELEMENTS INVOLVED IN THE EXHAUST AND AGING PROCESSES. THIS WORK RESULTED IN IMPROVED AND REASONABLY STABLE FILAMENT EMISSION AND HAS PROVIDED A MORE UNIFORM VALUE FOR ALL TUBES CONSTRUCTED.

Also, work has been continued in efforts to determine the amount of electrical output available from this type of tube. Initially, an alternating-current circuit was employed, but results were unsatisfactory due to excessive pickup of stray noise. A VTVM circuit next was tried and, with a single stage of amplification, the output was of the order of 15 micro-amperes per G acceleration. It is planned to perform further work in this direction with additional amplifier stages. Consideration is being given to a plan for employing a two-stage VTVM for testing the tubes without external loading so as to check the actual diaphragm distortion.

C. DYNAMIC BALANCE INDICATOR FOR VACUUM TUBE GYRO

This project was concluded during the July-August period with installation and adjustment of the amplitude or output indicator, installation of a suitable frequency meter, and final testing and calibration of the instrument itself.

It was noted that the high sensitivity of the frequency meter allows a reading when the relays on the input circuit are open. Since this spurious indication does not detract from normal operation of the unit, no attempt was made to correct the condition.

D. ANTENNA DESIGN AND CONSTRUCTION

The test vehicle flipper antenna design was completed. These antennas are of the flush-type for installation in the four fins of the vehicle. One of the antennas is mounted in a vertical fin for receiving the Doppler speed indicator signals at 72 megacycles with a second antenna being mounted in the other vertical fin for transmitting Doppler speed indicator signals at 144 megacycles. The two remaining antennas are mounted in the horizontal fins and are paralleled for transmitting telemetering signals at 77 and 87 megacycles simultaneously. Production of the prototype model of these antennas has been started.

A report entitled "VHF Airborne Antennas for Army Test Vehicle" (DEVF 4055) was issued culminating a study of the development of these flush-type antennas. Each of the antennas consists of a zig-zag metal strip inserted in the micarta flipper on the outer extremity of the four fins. A capacity-tuned autotransformer-type matching network is used to match the antenna to a 52-ohm coaxial line. Matching networks for the three lower frequencies are identical and are trimmed for the specific frequency by the variable condenser. The two

TELEMETERING ANTENNAS WERE PARALLELED TO ACHIEVE A BETTER RADIATION PATTERN. AN ISOLATION NETWORK IS PROVIDED TO ELIMINATE INTERACTION BETWEEN THE TWO TELEMETERING TRANSMITTERS WHICH USE THE SAME ANTENNA SYSTEM. THE IMPEDANCE MATCH FROM ANTENNAS TO FEED CABLE IS IN ALL CASES NEARLY PERFECT. THE RADIATION PATTERNS DO NOT HAVE THE DESIRED MAXIMUM LOBE TO THE REAR BUT ARE SUITABLE FOR GOOD OPERATION. RADIATION EFFICIENCY COMPARES WELL WITH THAT OF A RESONANT DIPOLE. ANOTHER ADVANTAGE OF THE DESIGN IS THAT THE ANTENNAS REQUIRE NO ADDITIONAL SPACE ON THE OUTSIDE OF THE VEHICLE AND PRODUCE NO EXTRA DRAG.

A REPORT TITLED "TELEMETERING RECEIVING ANTENNA ARRAY FOR ARMY TEST VEHICLE" (CVAC ZN-6002-003) CONTAINS A DESIGN DESCRIPTION OF A UNI-DIRECTIONAL TURNSTILE ANTENNA ARRAY DEVELOPED FOR RECEIVING TELEMETERING SIGNALS FROM THE TEST VEHICLE. SINCE THE SIGNAL FROM THE MISSILE IS LINEARLY POLARIZED, IT WAS NECESSARY TO INCORPORATE CIRCULAR POLARIZATION INTO THE ANTENNA BECAUSE OF ROLL OR OTHER CHANGES OF ATTITUDE OF THE MISSILE IN FLIGHT. THE DESIRED MODERATELY SHARP BEAM WAS PRODUCED BY USING TWO TURNSTILE RADIATORS BACKED BY PARASITIC REFLECTORS AND FED IN-PHASE. A SATISFACTORY IMPEDANCE MATCH WAS ATTAINED OVER A FREQUENCY BANDWIDTH GREATER THAN THAT REQUIRED. THE FEED SYSTEM IS MADE UP FROM SECTIONS OF 52- AND 72-OHM COAXIAL CABLE MOLDED TOGETHER AT THE INTERSECTIONS. MEANS HAVE BEEN PROVIDED FOR ROTATING THE BEAM IN BOTH AZIMUTH AND ZENITH TO ANY POINT ABOVE THE HORIZON WITH THE MEASURED GAIN OF THE ARRAY APPROXIMATELY 16 DB OVER A DIPOLE IN FREE SPACE.

E. CAMERA LOCATOR BEACON

CONSTRUCTION OF THE CAMERA LOCATOR BEACON FOR THE MX-774 TEST VEHICLE IS NEARLY COMPLETE. THE FINAL MODEL CONSISTS OF THE TRANSMITTER UNIT ASSEMBLED IN A BAKELITE BLOCK, 1 INCH x 2 INCHES x 2 1/2 INCHES IN SIZE PLUS THE NECESSARY BATTERIES TO FURNISH PLATE AND FILAMENT POWER. PLATE POWER IS SUPPLIED BY TWO 45-VOLT "HEARING AID" BATTERIES (BURGESS XX30E), WHILE FILAMENT POWER IS FURNISHED BY A SMALL 6-VOLT DEWAR STORAGE BATTERY. FINAL FITTING OF THESE UNITS INTO THE NOSE SECTION OF THE MISSILE IS NOW BEING DONE BY THE DRAFTSMEN. ACTUAL WEIGHT OF THE COMPLETE BEACON IS 3 1/4 POUNDS. SERVICE LIFE OF THE BEACON WILL EXCEED TEN HOURS. FIELD TESTS OF THE USEFUL RANGE OF THE BEACON ARE AWAITING DELIVERY OF SUITABLE RECEIVING EQUIPMENT FROM THE AMC.

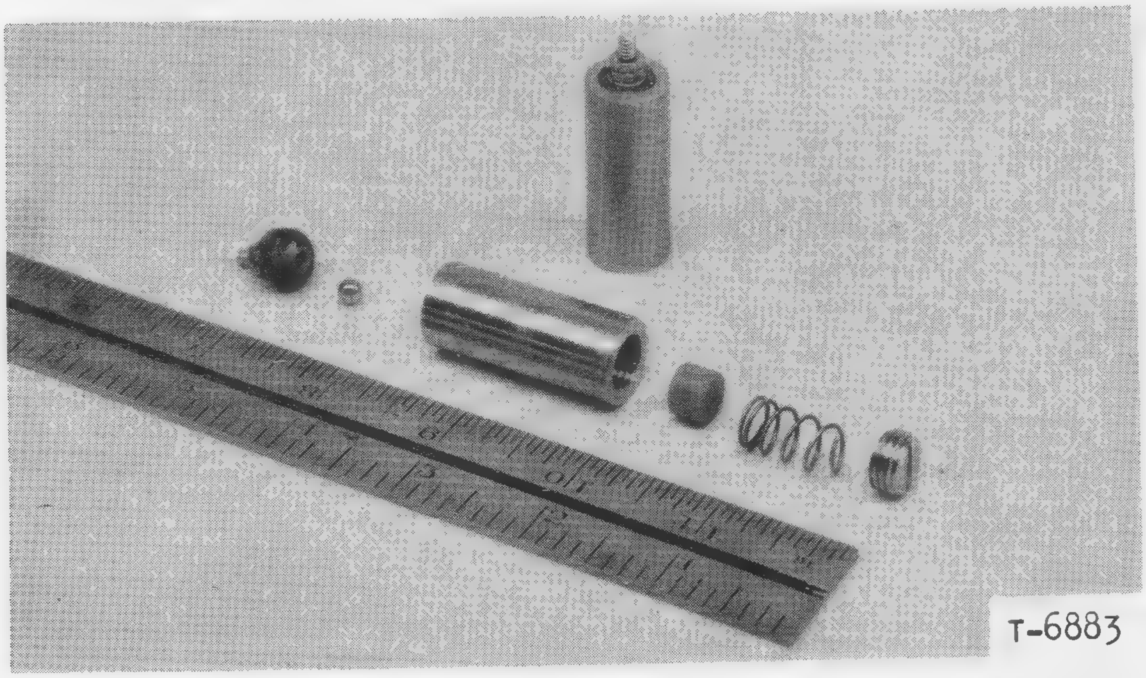

FIG. 29 -- IMPACT SWITCH FOR LOCATOR BEACON TRANSMITTER

AN "IMPACT" SWITCH, AS SHOWN IN FIGURE 29, HAS BEEN DEVELOPED FOR INCLUSION IN THE TRANSMITTER UNIT TO MAKE THE BEACON OPERATIVE EVEN THOUGH THE NORMAL SWITCHING CIRCUIT FAILS TO START IT DURING FLIGHT. THIS IMPACT SWITCH CONSISTS OF A STEEL BALL HELD IN A METAL RECESS BY A LOADING SPRING. BOTH RECESS AND BALL ARE SURROUNDED BY BUT INSULATED FROM AN ELECTRICALLY CONDUCTIVE TUBE OR RING. A SUFFICIENT SHOCK WILL FORCE THE BALL OUT OF THE CUP AND WEDGE IT BETWEEN THE EDGE OF THE CUP AND THE SURROUNDING RING. THIS IMPACT SWITCH WILL BE CONNECTED IN PARALLEL WITH THE NORMAL SWITCH.

SELECTION OF THE ANTENNA SYSTEM FOR THE CAMERA LOCATOR BEACON HAS BEEN REDUCED TO A CHOICE BETWEEN A FLUSH MOUNTING "SLOT" TYPE ANTENNA AND A SYSTEM CONSISTING OF THREE RETRACTABLE QUARTER-WAVE ANTENNAS SPACED SYMMETRICALLY AROUND THE NOSE SECTION OF THE MISSILE. MODELS OF EACH OF THE SYSTEMS HAVE BEEN CONSTRUCTED AND ARE CURRENTLY UNDERGOING TESTS TO DETERMINE THEIR RELATIVE MERITS FOR THIS APPLICATION.

F. TRACKING RADAR RELAY BEACON

THE GENERAL OBJECTIVE OF THIS PROJECT IS TO DESIGN AND CONSTRUCT A COMPACT "S" BAND AIRBORNE RADAR BEACON HAVING SUFFICIENT SENSITIVITY AND POWER TO ADEQUATELY PERFORM A TRACKING-ASSIST FUNCTION IN THE IN THE MX-774 MISSILE.

A BEACON WHICH CONSISTS OF A RECEIVER, SHOWN IN FIGURE 30 AND A TRANSMITTER, FIGURE 31, BOTH HOUSED IN A PRESSURIZED CONTAINER AS SHOWN IN FIGURE 32, HAS BEEN CONSTRUCTED AND HAS SATISFACTORILY MET ALL TESTS NECESSARY TO SHOW ITS EFFECTIVENESS AND RELIABILITY. THE OVERALL SPACE REQUIREMENTS OF THIS UNIT ARE 8 1/2 INCHES x 8 1/2 INCHES x 11 INCHES. WEIGHT IS 12 POUNDS INCLUDING THE MOUNTING BRACKETS. POWER IS SUPPLIED FROM AN EXTERNAL SOURCE. THE TEMPERATURE RANGE TO WHICH THE BEACON WAS SUBJECTED IN THERMAL TESTS RANGED FROM MINUS 45 DEGREES TO PLUS 185 DEGREES, FAHRENHEIT. THE UNIT WAS TESTED IN A DEPRESSURIZED CONDITION OUTSIDE OF ITS PRESSURIZED CONTAINER UNDER FAR MORE SEVERE CONDITIONS THAN IF IT WERE PRESSURIZED FOR A FLIGHT OF SHORT DURATION.

DIFFICULTIES ENCOUNTERED WITH THE RADAR BEACON WERE PRIMARILY THOSE OF PACKAGING, ELIMINATION OF NOISE AND REGENERATIVE EFFECTS, AND THE SELECTION OF COMPONENTS THAT WOULD WITHSTAND THE ANTICIPATED TEMPERATURE RANGES. IT WAS FOUND NECESSARY TO PROVIDE THE BEACON RECEIVER WITH A FILTER THAT WOULD ELIMINATE ANY BEACON RESPONSE TO SIGNALS OTHER THAN THE TRACKING RADAR. THIS INCLUDES OTHER RADAR OPERATIONS IN THE VICINITY AND ADJACENT "S" BANDS AND "X" BANDS. DESIGN AND CONSTRUCTION OF THIS FILTER IS NOW IN PROGRESS.

A FURTHER TEST CONTEMPLATED FOR THE BEACON IS THAT OF A TEST FLIGHT IN A C-46 TRANSPORT USING THE ANTENNAS TO BE INSTALLED IN THE MISSILE AND IN CONJUNCTION WITH AN SCR-584 GROUND RADAR. THE EXTERNAL PORTABLE POWER SUPPLY UNIT HAS BEEN COMPLETED AND IS AVAILABLE FOR TEST PURPOSES.

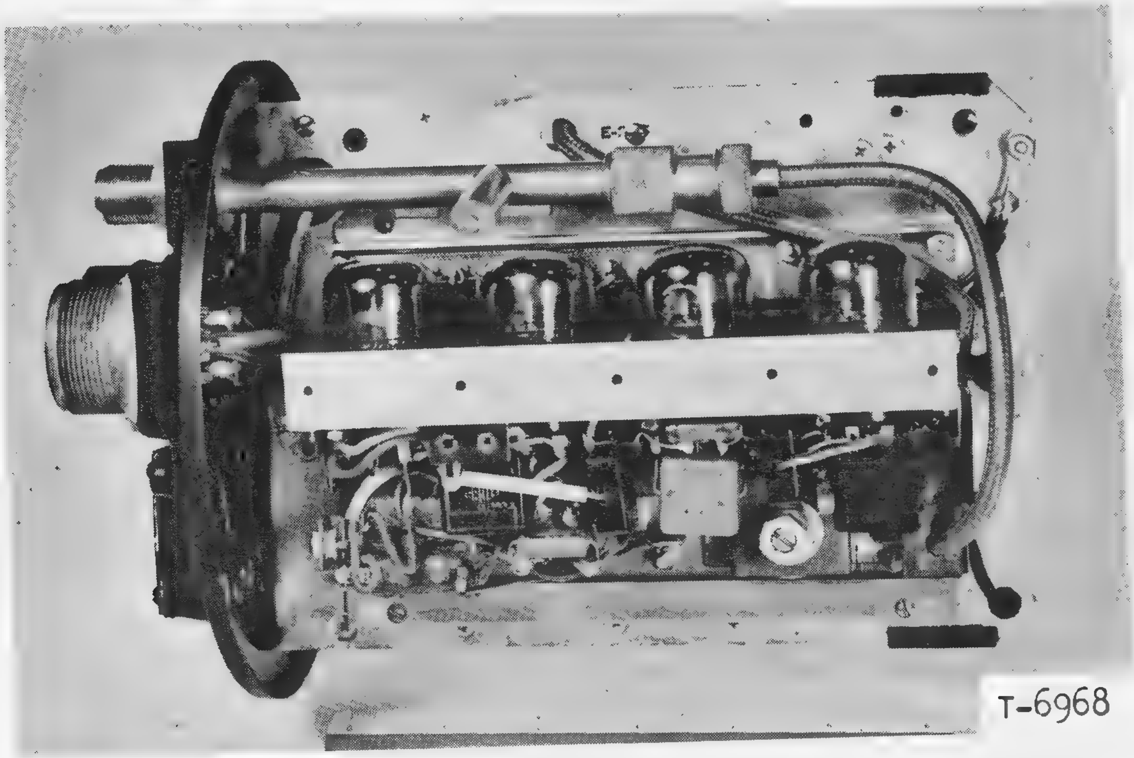

FIG. 30 -- RECEIVER UNIT FOR MX-774 RADAR RELAY BEACON

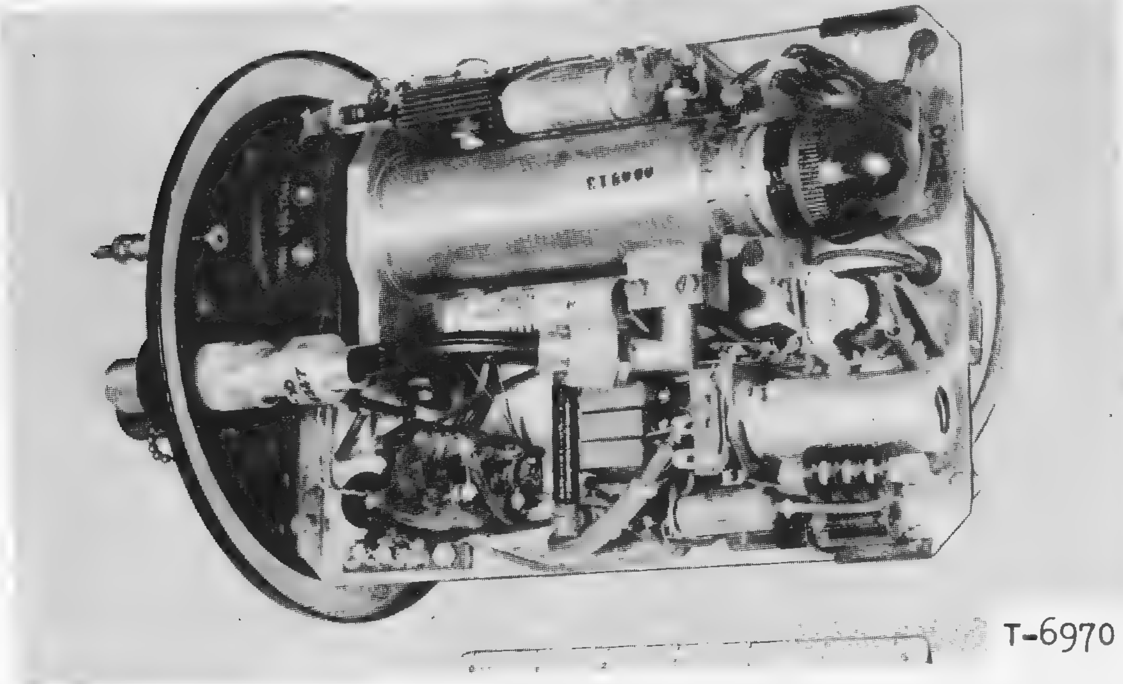

FIG. 31 -- TRANSMITTER UNIT FOR MX-774 RADAR RELAY BEACON

FIG. 32 -- MX-774 RADAR BEACON HOUSED IN PRESSURIZED CAN

SECTION IX
TEST OPERATIONS

A. STATIC TEST PROGRAM

The static firing test site at Point Loma, started during the report period, is progressing rapidly. By the end of August all grading and excavating had been finished, blockhouse floor and walls poured, static test tower completed (including derrick leg shields and spray-water plumbing), and the approach road oiled. Figure 33 shows the test site. Plumbing and wiring of the area was well under way with the Navy portable generator in place. N.E.L. is providing 24 hour patrol and fire fighting services. Telephone trunk extension from an adjacent gun battery was OK'd by the Army.

Instrumentation for the blockhouse and proof tower has been started.

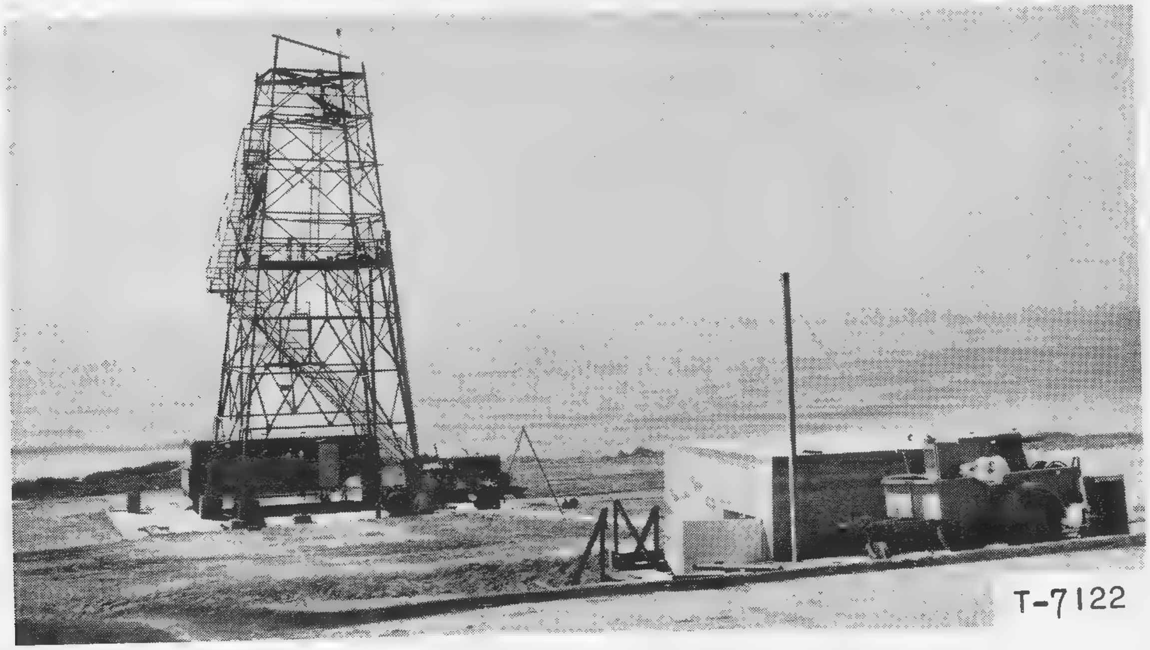

FIG. 33 -- POINT LOMA STATIC FIRING TEST SITE AT FORT ROSECRANS, SAN DIEGO

An installation is being made to locate cameras for photographing the test cell instrument panel and also the missile during static runs. One 35-mm Bell and Howell Eyemo camera will make a record of the panel. One Eyemo and one 16-mm Bell and Howell GSAP camera will photograph the missile from locations in a window frame inside the test cell. Additional external cameras will photograph the missile from vantage points in the tower and on the roof of a nearby shed. Colored moving pictures will be taken by some of these cameras.

Procedures and special instructions required for safe and efficient operation of the static Test Vehicle are in process.

(1) Configuration of Missile Power Plant Prior to Start
(2) Operation of Equipment Used During Starting
(3) Power Plant Firing Procedure - Sequence of Operations
(4) Power Plant Operating Limits
(5) Normal Shut-Down Procedure
(6) Emergency Shut-Down Procedure
(7) Static Test Program

The power plant acceptance test procedure has been written and released for distribution. This test will be coordinated with tests for other groups into one general missile acceptance test.

B. FLIGHT TEST PROGRAM

The preliminary detailed program for flight testing of the first MX-774 has been released; launching is assumed to take place at White Sands. Procedures for pre-flight check-outs and for launching of a missile are being prepared. Already in work are:

(1) Cold Check of Propulsion System Prior to Flight
(2) Launching of the Missile
(3) Procedure During Flight
(4) Procedure Following Flight

Necessarily, the procedures will be tentative until after completion of static firing tests. Timing sequence and method for triggering fuel cut-off, parachute release, and detonation of self-destruction device are being worked out to ensure desired results in any eventuality with minimum complication of command channels.

The launching table was redesigned to incorporate a water-jet after-shut-down extinguishing system. Work on that portion of the flight test instrumentation to be utilized during static firing tests has been started.

The nose instrument panel installation has been released for the static test Missile only; a photo-recorder panel test pattern has given good test photographs. Installation of photo-recorder panel instruments is shown in Figure 34.

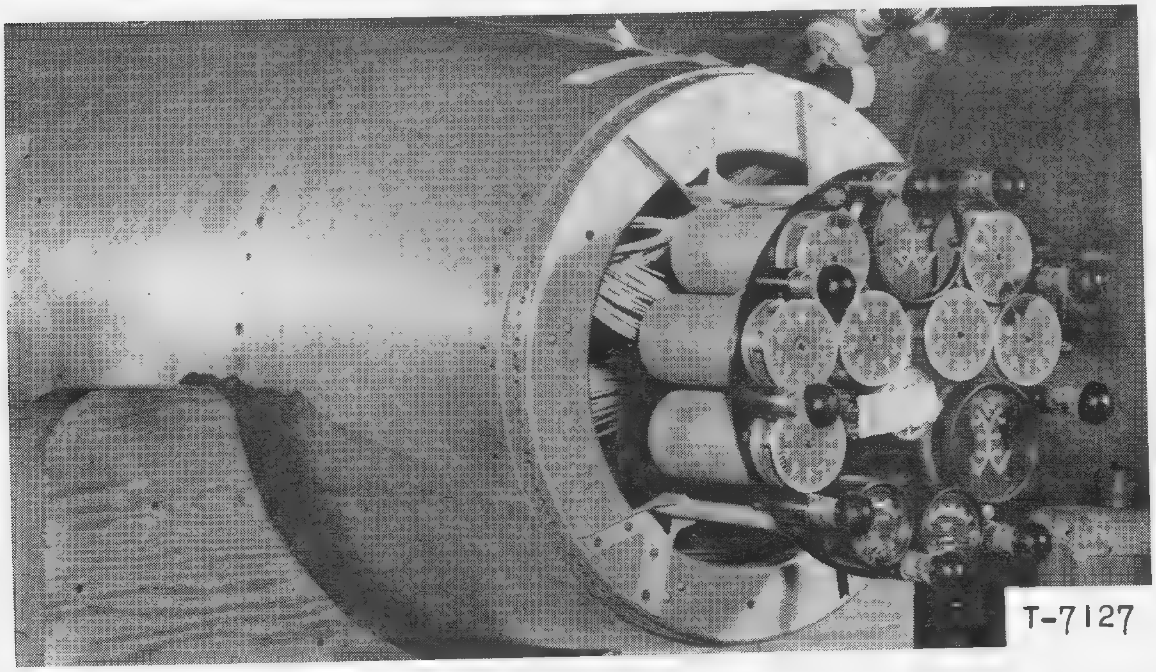

FIG. 34 -- PHOTO-RECORDER INSTRUMENT PANEL IN NOSE OF MX-774 B TEST VEHICLE

SECTION X

PROJECTED WORK PROGRAM

WORK TO BE INITIATED, CONTINUED, OR COMPLETED DURING THE NEXT WORK PERIOD INCLUDES THE FOLLOWING ITEMS:

(1) CONTINUATION OF AERODYNAMIC ANALYSIS AND OF GUIDANCE, CONTROL, AND TRAJECTORY RANGE STUDIES.

(2) FURTHER EQUIPMENT DEVELOPMENT FOR THE STABILIZATION AND CONTROL SYSTEM.

(3) CONTINUATION OF EXPERIMENTS WITH THE PRECISION MISSILE POSITION TRACKING EQUIPMENT.

(4) INAUGURATION OF RANGE DOPPLER BENCH TESTS.

(5) COMPLETION AND TEST OF COMMAND GUIDANCE CONTROL SYSTEM FOR TEST MISSILE NO. 2.

(6) COMPLETION OF THE TELEMETERING GROUND STATION TRUCK AND TRY-OUT AT THE SITE.

(7) INSPECTION OF COMPLETE STATIC FIRING TEST MISSILE AND INSTALLATION OF MISSILE IN THE TEST STAND AT POINT LOMA.

(8) COMPLETION OF WORK AT THE STATIC FIRING TEST SITE AT POINT LOMA AND CHECK-OUT OF CONTROL AND INSTRUMENTATION CIRCUITS.

(9) RELEASE OF REMAINING STATIC TEST PROCEDURES.

(10) CONFERENCE ON FLIGHT TEST FACILITIES AND AVAILABLE INSTRUMENTATION OF WHITE SANDS.

TECHNICAL DATA

A. INTERNAL REPORTS

CVAC ZN-001	A STUDY OF RANGE MEASUREMENT SYSTEMS
DEVF 4055	VHF AIRBORNE ANTENNAS FOR ARMY TEST VEHICLE
CVAC ZN-6002-003	TELEMETERING RECEIVING ANTENNA ARRAY FOR ARMY TEST VEHICLE

B. PROJECT ACTIVITY REPORTS

REF.	TITLE	CVAC NO.
1	GROUND-TO-GROUND MISSILE PROGRESS FOR MAY 1946	1496-1
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3	GROUND-TO-GROUND MISSILE PROGRESS FOR JUL 1946	1496-3
4	GROUND-TO-GROUND MISSILE PROGRESS FOR AUG 1946	1496-4
5	GROUND-TO-GROUND MISSILE PROGRESS FOR SEP 1946	1496-5
6	GROUND-TO-GROUND MISSILE PROGRESS FOR OCT 1946	1496-6
7	GROUND-TO-GROUND MISSILE PROGRESS FOR NOV 1946	1496-7
8	GROUND-TO-GROUND MISSILE PROGRESS FOR DEC 1946	1496-8
9	GROUND-TO-GROUND MISSILE PROGRESS FOR JAN 1947	1496-9
10	GROUND-TO-GROUND MISSILE PROGRESS FOR FEB 1947	1496-10
11	GROUND-TO-GROUND MISSILE PROGRESS FOR MAR-APR 1947	1496-11
12	GROUND-TO-GROUND MISSILE PROGRESS FOR MAY-JUN 1947	1496-12

C. REFERENCES

REF A. THE ANALYSIS AND SYNTHESIS OF LINEAR SERVOMECHANISMS, BY A. C. HALL

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